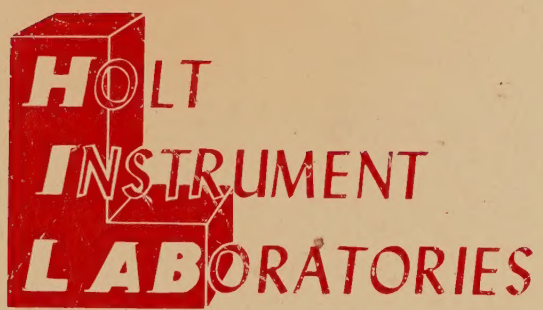
PMSL

AVS 321



CLAIM FOR DAMAGE SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also notify Holt Instrument Laboratories or the local Representative immediately. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by warranty. All shipments of Holt Instrument Laboratory equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

TECHNICAL SPECIFICATIONS

REGULATION RANGE:	1 volt to 1000 volts RMS 35cps to 2KC. 1 volt to 300 volts RMS 35 cps to 10 KC.
REGULATION ACCURACY:	Regulated voltage is equal to the dial setting ± (0.1% + 2mv.) from 1 volt to 300 volts. From 300 volts to 1000 volts accuracy is ± 0.25%.
STABILITY:	The output will remain within the above absolute voltage tolerances for thirty days under laboratory conditions. Long term drift may be corrected by a simple adjustment against a primary lab. standard.
OUTPUT WAVEFORM:	Sinusoidal.
DISTORTION:	0.15% 1 volt to 300 volts + input distortio 0.5% 300 volts to 1000 volts Lowest distortion will be obtained when driven from an oscillator having less than 0.1% distortion.
INTERNAL OSCILLATOR:	60 cps Harmonic distortion less than 0.1%.
REGULATION RESPONSE:	The regulator has a time constant of 200 milli-sec. and a damping factor of 0.6.
OUTPUT CURRENT:	Unity power factor 10 Amps. @ 1 volt 3 Amps. @ 1.1 volt to 10 volts 300 Ma. @ 11 volts to 100 volts 100 Ma. @ 101 volts to 300 volts 30 Ma. @ 301 volts to 1000 volts
REQUIRED DRIVING VOLTAGE:	1 to 2 volts RMS 35cps to 10 KC.
POWER SOURCE:	105 volts to 125 volts 60cps. 550 watts
MECHANICAL:	19 inch rack mounting 14 inches high 15 inches deep

Since the output is continuously variable in frequency as well as voltage, complete information about the response of the unit or system under test may be obtained including the effects of resonance and time constants that lie near the normal operating frequency but may not be discovered under fixed frequency testing.

TABLE OF CONTENTS

FRONTISPIECE

WARRANTY

TECHNICAL SPECIFICATIONS

GENERAL DESCRIPTION SECTION 1

General Description 1-1

Damage in Shipment 1-1

Power Cable 1-1

Power Line Voltage 1-2

OPERATING INSTRUCTIONS SECTION 2

Terminals and Controls 2-1

Operation 2-2

Driving Oscillator 2-5

Grounding and Interference 2-6

THEORY OF OPERATION SECTION 3

General 3-1

Voltage Control 3-2

AC to DC Converter 3-4

Audio Filter 3-7

Servo Amplifier 3-8

Power Amplifier 3-10

Power Supply 3-11

60 cps Internal Oscillator 3-12

CALIBRATION SECTION 4

Standards 4-1

Procedure 4-1

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MAINTENANCE SECTION 5

Overhaul and Factory Adjustment Procedure 5-1

Waveforms 5-13

Voltage Tables 5-16

ILLUSTRATIONS SECTION 6

Front Panel Controls 6-1

Rear View 6-2

Top View 6-3

60 Cycle Oscillator 6-4

AC to DC Converter 6-4

Servo Amplifier 6-5

Power Amplifier 6-6

Power Supply Regulator Modules 6-7

Bottom View 6-8

TABLE OF REPLACEABLE PARTS

FACTORY TEST DATA

SCHEMATICS

Block Diagram

Voltage Control

AC to DC Converter

Servo Amplifier

Power Amplifier

Power Supply Regulators

Power Supply

1-1 GENERAL DESCRIPTION

The model AVS-321 is an extremely stable electro-mechanical audio frequency voltage regulator. It includes a high quality audio power amplifier with a special multi-tap output transformer. It should be driven by a low distortion audio oscillator. Together these units form a precision source of sine wave audio frequency voltage. The unit will regulate voltages from 1 volt to 1,000 volts at frequencies from 35 cycles to 10,000 cycles.

The instrument may be used as a source for calibrating other A. C. instruments. In conjunction with an accurate A. C. voltmeter it may be used for testing components such as transformers, condensers and inductors. This method of component testing is much faster than bridge testing and tests may be made over a broad range of frequencies. The instrument may also be used as a source for frequency response testing of amplifiers and audio frequency filters, making faster, more accurate readings possible.

1-2 DAMAGE IN SHIPMENT

Examine the instrument carefully on arrival. If there is any apparent damage refer to "Damage in Shipment" at the front of this manual, for instructions.

1-3 POWER CABLE

A three conductor power cord is supplied with the instrument terminated in an NEMA recommended, polarized three prong male connector. The large rectangular pin

should connect to the common side of the A.C. power line; the small rectangular pin to the hot side of the line. The chassis of the instrument is connected to the large round pin of the connector. It is important that this be connected to a ground connection which is returned to earth with a minimum of noise. Large amounts of noise or 60 cycle voltage on the instrument chassis will effect the accuracy of regulation. See the operating instructions for procedures to test the amount of noise present in the regulating loop.

1-4 POWER LINE VOLTAGE

The instrument is designed for operation on power line voltage of 115 volts plus or minus 10%. If line voltage is consistently high or low the power transformers are provided with taps for 105 and 125 volts. In using these taps care should be taken to prevent prolonged operation on high or low line voltages.

SECTION II
OPERATION

2-1 TERMINALS AND CONTROLS

Power Switch: This toggle switch connects power to the primary of the filament transformer and to the heater of a thermal time delay relay which energizes the plate power transformer after 30 seconds. When the time delay actuates, the ready light will turn on.

Stand by Switch: The Stand by switch connects power to the servo motor and chopper, and connects the input to the power amplifier. The Operate light will turn on when this switch is placed in the operate position.

Fuses: The 2 amp fuse on the left side of the panel is in the primary circuit of the filament transformer. The 4 amp fuse on the right side of the panel is in the plate and servo motor supply circuits.

Decade Output Control: The five controls at the top of the panel control the output voltage by selecting the proper taps on the output transformer and the precision resistors of the regulator input attenuator.

Load Control: The load watts switch controls a resistive load on the power amplifier.

External Oscillators - 60 cycle switch: This switch connects the input of the unit to the front panel terminals or to the internal 60 cycle weinbridge oscillator.

TERMINALS:

Input: The three terminals on the left side of the instrument are connected to the input of the power amplifier through the servo driven potentiometer used to regulate the A.C. Signal. The left pair is the amplifier input and signal ground. The right hand terminal of this group is the chassis ground.

Output Terminals: The four terminals on the right hand side of the panel are the output voltage connections. The GND term is Chassis Ground. The common and output terminals are used for all output voltages above 1.000 volts. The 10A terminal may be used for obtaining up to 10 amps of current when the output is set to 1 volt. It may also be used as a stable but uncalibrated source of current for phantom load wattmeter calibration. When used this way, the wattmeter voltage terminals are connected to the output and common terminals and the current coil is connected through a Standard Ammeter and a control rheostat to the 1 volt, 10 amp terminal. The total power drawn from the voltage and current terminals should not exceed 30 watts.

2-2 OPERATION

With the power turned off connect a high quality, low distortion oscillator to the AVS-321 as shown in figure 2-2.1. Turn on the oscillator and set its output voltage to approximately 1.0 volts and the desired frequency. Turn on the AVS-321 leaving the operate stand

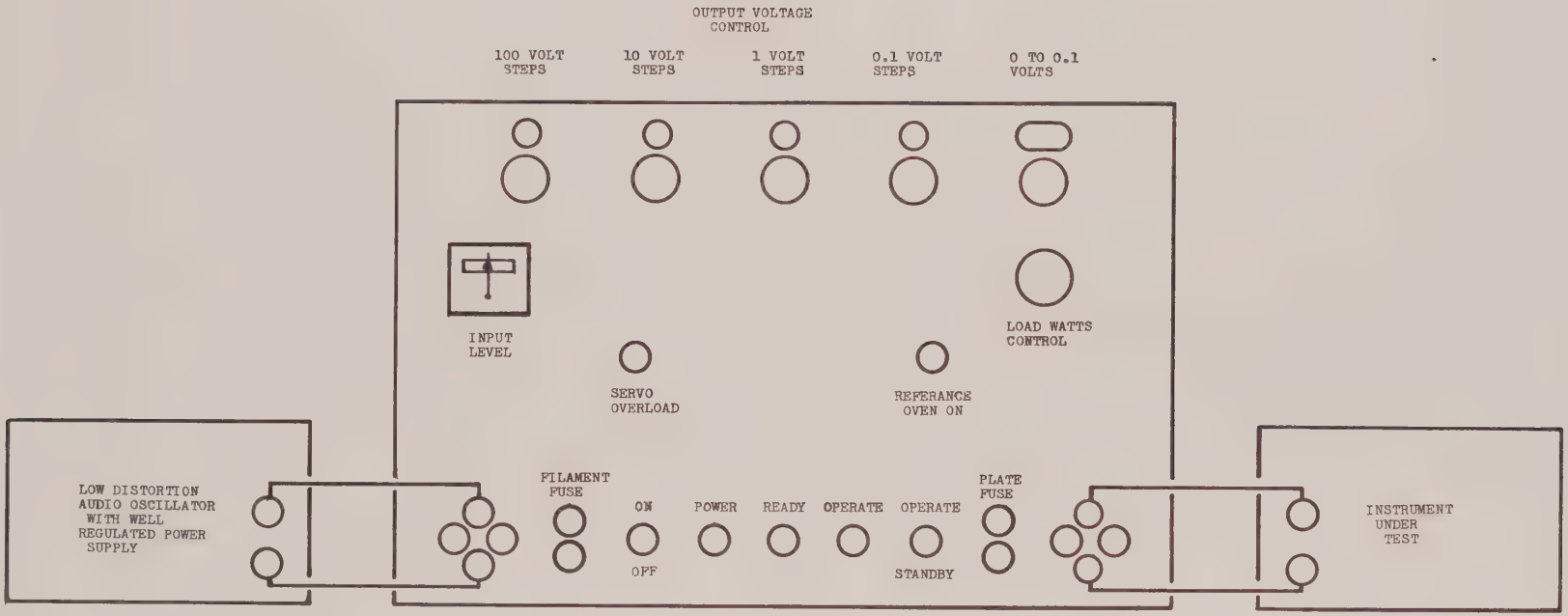

OUTPUT VOLTAGE CONTROL
100 VOLT STEPS
10 VOLT STEPS
1 VOLT STEPS
0.1 VOLT STEPS
0 TO 0.1 VOLTS
INPUT LEVEL
SERVO OVERLOAD
REFERANCE OVEN ON
LOAD WATTS CONTROL
LOW DISTORTION AUDIO OSCILLATOR WITH WELL REGULATED POWER SUPPLY
FILAMENT FUSE
ON
OFF
POWER
READY
OPERATE
OPERATE
STANDBY
PLATE FUSE
INSTRUMENT UNDER TEST

Figure 2-2.1

by switch in the stand by position. Set the control switches to the desired output voltage. Set the load watts switch to the approximate power required by the load under test. This setting is not critical. An accuracy of plus or minus 3 watts will not affect the output voltage accuracy.

When the ready light turns on the unit may be switched to operate. The output of the low distortion oscillator may vary from .75 to 1.25 volts as indicated by the green region on the input level meter. The regulator will completely correct for variations within these limits. If the oscillator output varies too much or too fast, the regulator overload light will glow in the panel.

In the voltage range from 1.1 to 9.9 volts slightly more care must be taken to assure proper oscillator input voltage. At any voltage in this range the oscillator output should be increased, then decreased while watching the overload light to determine the regulating range. The oscillator output should then be centered approximately between these maximum and minimum limits. This will not always be centered in the green region of the input meter.

Changing Voltage:

To change the regulator voltage, first place the AVS-321 in stand-by. Adjust the control switches to the desired voltage. Then switch the AVS-321 back to operate.

NOTE: The output voltage is removed from the terminals when the unit is in stand-by.

Changing Frequency:

The output frequency may be changed by changing the oscillator frequency. No readjustment of the AVS-321 is necessary. Place the AVS-321 in Stand-by when changing oscillator range.

Input Oscillator Characteristics:

The AVS-321 is a power amplifier with a servo type voltage regulator in the feed back loop. Necessarily this regulator has a finite time constant and resolution. The time constant of the AVS-321 is approximately 0.2 sec. The system has a damping factor of 0.6. Servo dead space is approximately 0.03%. Due to these factors small short term variations in the input signal will not be corrected by the regulator.

In most calibration work, where thermo-couple or moving coil instruments are being calibrated, the time constant and damping of the meter being read are long enough to filter out most of these short term transients.

When calibrating the new expanded scale and digital instruments which have extremely high resolution and short time constants any small variation in the oscillator output will be seen as a fast fluctuation in the reading or a cyclic variation in the least significant digit of the digital meter.

If these variations are a problem we recommend the use of Holt Instrument Laboratories Model AO-400 fixed frequency 400cycle oscillator or Model AO.1 variable frequency oscillator. These oscillators are amplitude stabalized for very low short term jitter.

Grounding and Interference:

To test the instrument for the presence of excessive 60 cycle hum in the ground circuits connect an oscilloscope to test points TP 101 and TP 102 on the servo amplifier board. TP 101 is the grounded terminal. The peak to peak voltage at this point should not exceed 50 milli-volts when the servo is at null with the instrument in operation at a frequency of 1,000 cycles. With the scope sweep at 2 milli-seconds per Cm. and sync on the line, the wave form should be a distorted 60 cycle voltage. Forcing the servo gear to one side or the other with the finger will make this error signal increase and shift phase by plus or minus 90 degrees. A change of one hundred milli-volts in the peak to peak value of this wave form from its magnitude at null is equal to a change of approximately 0.1% in the regulated A.C. at the output of the AVS-321.

The instrument is wired with the output, regulator, and chassis grounds connected only by the front panel ground links. This ground connection can be made at a remote point as part of a radial ground system, but it must be a low resistance connection introducing a minimum of noise and hum as extra voltages inserted in this connection will affect calibration.

Setting the Servo Gain:

The gain of the servo amplifier will affect the servo dead space and in some cases the overall short term stability of the unit. This adjustment is accurately set at the factory as part of the calibration procedure. However, occasionally this may demand resetting, due to tube aging.

To do so, connect an oscilloscope to T.P. 101 and observe the error signal, unit in operate, starting with R-118 (Servo gain adjustment) fully counter clockwise. The servo motor is fully disabled and the error signal will be large, dependent on the difference between the output of the AC-DC converter and the reference voltage. Adjust R-118 by turning it clockwise until the servo motor seeks a null position. The error signal at this point should reduce in amplitude to nearly a straight line. Occasionally it may become larger as the servo attempts to stabilize the output signal amplitude. Continue to turn R-118 until a point is reached where the error signal amplitude becomes large again. At this point the servo gain is excessive and the servo gear will jitter rapidly. Turn the servo gain adjustment R-118 back until the jitter stops.

To insure that this control is properly set, place a finger against the servo gear, (below the unit on the left hand side). The gear should be stiff and require some pressure to move it off this null point. It should not be jittering. The optimum setting is achieved when maximum stiffness is attained without allowing the servo to jitter.

SECTION III
THEORY OF OPERATION

3-1 GENERAL

The AVS-321 consists of the following basic assemblies:

a. The precision Voltage Control permits continuous selection of output potentials from zero to 1000 volts. It also attenuates the output voltage to the one volt AC Converter input.

b. The AC to DC Converter rectifies this signal and amplifies it with a highly stable conversion gain.

c. The Audio Filter filters the half wave rectified output of the Converter to a smooth DC signal having less than 0.1% peak to peak ripple.

d. The Servo Amplifier compares this DC signal to a highly stable DC reference and amplifies the difference or error to provide driving power for the servo motor.

e. The Servo Motor and pot assembly act as an automatic gain control for the input to the power amplifier, adjusting the gain of the power amplifier to maintain its output at exactly the desired level.

f. The Power Amplifier produces full output power continuously with less than 0.1% harmonic distortion. The frequency response is plus or minus one db from 35 cycles to 10,000 cycles. The output of the power amplifier is monitored and controlled by the regulator system parts (a) through (e) above.

g. The Power Supply furnishes all the AC and DC power to operate the instrument.

3-2 VOLTAGE CONTROL

The AVS 321 provides a range of output voltages from zero to 10,000 volts at the input frequency. The selected output is continously variable with the four decade switches and a variable resistor. The decade switches select the proper output transformer tap or taps to give the desired voltage. The block diagram demonstrates how various taps are connected and added to achieve all possible potentials. The decade switches in addition to selecting the proper output voltage, select the attenuator resistor or resistors permitting a very accurate division of the output voltage to the one volt level fed to the AC Converter.

In the voltage range from 1.1 volts to 9.9 volts, the input gain of the power amplifier is adjusted by the 0.1 volt decade switch to produce 0.1 volt steps in the output.

The attenuator is a constant current attenuator, made up of special, precision, wire wound resistors. These resistors have a very small time constant with a correspondingly good frequency response. The resistors are bridged at the time of assembly to insure accuracy of three-hundredths of a percent or better.

The attenuator is mechanically arranged for a minimum of stray capacitance both from the resistor to ground and shunt capacity across the resistors. The resistors are rigidly mounted so that capacitive effects are stable and can be compensated for at the time of calibration. Subsequently, it is very important that the

physical position of the attenuator components be maintained between high frequency calibrations. Because of the lower impedances used at the lower voltages, they are somewhat less critical with respect to stray capacitance.

The output of the attenuator is 1 volt RMS into a ten thousand ohm load. The one volt is maintained at all of the output terminal voltages by selecting the proper attenuator resistors. This selection is done automatically by extra switch sections as the desired output voltage is selected. At one volt selected output, there are no attenuator resistors in the circuit, but rather the one volt is fed directly from the output terminals to the ten thousand ohm load in the AC Converter. At voltages above one volt, the proper fixed attenuation is provided. A trim pot is provided in the output section to set the exact attenuator ratio. Caution is urged in that this adjustment be made only at calibration where the instrument's output can be checked against primary standards. If a 0.05% A.C. to D.C. transfer standard is not available this trim may be adjusted with a Wheatstone Bridge. (See calibration procedure).

The ten thousand ohm load at the AC Converter is shunted with a high frequency compensating network. These components provide the necessary compensation for one volt selected output. Their size is peculiar to each individual unit and is factory set. At voltages above one volt, high frequency compensation is provided by similar networks inside the attenuator enclosure itself.

These components are selected during factory calibration, in ten volt increments up to three hundred volts and should not require readjustment unless physical position of attenuator components is disturbed.

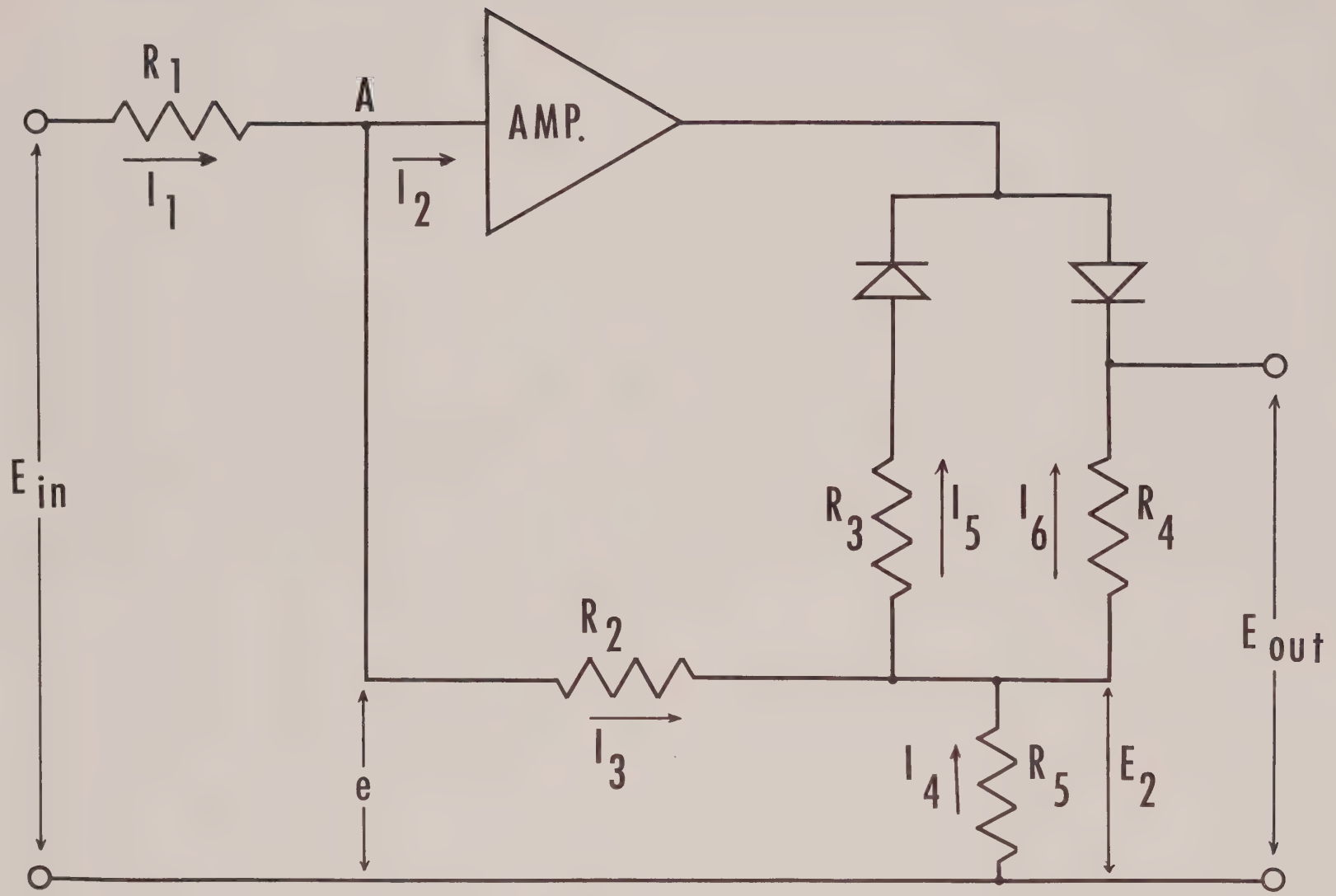
3.3 THE A.C. TO D.C. CONVERTER

The A.C. to D.C. converter is a high gain broad band amplifier with two silicon diodes in a feedback loop which reduces the closed loop gain of the amplifier to 28 db. The diodes are arranged so that the positive half cycle of the feed-back current flows through a precision resistor and the output of the converter is taken across this resistor. The output is therefore a halfwave rectified voltage which is proportional to the half cycle of the feed-back current. Due to the high gain of the amplifier, the summing junction at the input of the amplifier is held very close to zero potential and since there is no current flowing in the grid circuit of the input tube, the input and feedback currents are equal and the output voltage of the A.C. to D.C. converter is a function only of the input voltage and the values of the precision resistors located in the feedback loop. Refering to Figure 3-2 the circuit operates in accordance with the following equations.

Since the input grid draws no current

eq. 3.3.1 $I_2 = 0$ Therefore $I_1 = I_3$

eq. 3.3.2 $$\frac{E_{in} - e}{R_1} = \frac{e - E_2}{R_2}$$



Block Diagram
A.C. to D.C. Converter
Fig. 3-3-1

Solving 3.3.2 for E_2

eq. 3.3.3 $$E_2 = -\frac{R_2}{R_1} E_{in} + e\left(1 + \frac{R_2}{R_1}\right)$$

Let K equal amplifier gain from point A to B.

eq. 3.3.4 $$e = -\frac{E_2}{K}$$ Where the minus denotes phase inversion in the amplifier.

And since $R_1 = R_2$

eq. 3.3.5 $$E_2 = -E_{in} - \frac{2E_2}{K}$$

Or

eq. 3.3.6 $$E_2 = -E_{in}\left[\frac{1}{1 + \frac{2}{K}}\right]$$

During the positive half cycle of the amplifier output

eq. 3.3.7 $$\frac{E_2 - E_{out}}{R_4} = \frac{e - E_2}{R_2} + \frac{0 - E_2}{R_5}$$

Substituting eq. 3.3.4 in eq. 3.3.7 and solving for E_{out}

eq. 3.3.8 $$E_{out} = E_2 + E_2 \frac{R_4}{\frac{R_2 R_5}{R_2 + R_5}} + \frac{E_2}{K}\frac{R_4}{R_2}$$

During the negitive half cycle of the amplifier output, assuming perfect diodes;

eq. 3.3.9 $I_6 = 0$ and eq. 3.3.10 $E_{out} = E_2$

from 3.3.6 if E_{in} has no D.C. component E_2 has no D.C. component and the positive half cycle of E_2 in the first factor of eq. 3.3.8 is exactly canceled by the negitive half cycle of eq. 3.3.10

Theory of Operation

In this instrument $R_4 = R_3$ and $E_2 = 1$ volt RMS therefore the factor;

eq. 3.3.11 $$\frac{E_2}{K}\frac{R_4}{R_3} = \frac{1}{K}$$

and the output D.C. voltage equals the half wave rectified average of;

eq. 3.3.12 $$E_{out} = E_2 \frac{R_4}{\frac{R_3R_5}{R_3 + R_5}} + \frac{1}{K}$$

substituting eq.3.3.6 in eq. 3.3.12

eq. 3.3.13

$$E_{out} = - E_{in} \frac{R_4}{\frac{R_3R_5}{R_3 + R_5}} \left[\frac{1}{1 + \frac{2}{K}}\right] + \frac{1}{K}$$

The ratio $$\frac{R_4}{\frac{R_3R_5}{R_3 + R_5}} = 10\frac{\pi}{\sqrt{2}}$$ which is the conversion factor from the RMS input voltage to the average of the half wave rectified voltage E_{out}. This factor causes E_{out} to equal ten volts D.C. when E_{in} equals one volt RMS. Since K is equal to 2000 the half wave rectified value of 1/K equals 0.225 milli-volts and may be neglected.

THE DIODES:

The silicon diodes used have a back resistance of greater than 100 meg Ω and a forward resistance of less than 1000 Ω.

The forward resistance appears in series with the output of the amplifier thereby increasing its output impedance. Doubling diode resistance at this point will only cause a 10% reduction in K and diode forward resistance changes may be neglected.

The back resistance appears in shunt with R_4 and if it were to decrease from 100 megohms to 10 megohms it would cause a change of 0.1% in the output voltage.

AMPLIFIER GAIN:

From eq. 3.3.13 it may be seen that amplifier gain effects the A.C. to D.C. conversion ratio in two ways. It has been shown that for values of K of greater than 1000 the factor 1/k may be neglected. The factor $\frac{1}{1 + \frac{2}{K}}$

is equal to 0.999 for a gain of 2000. If the amplifier gain drops to 1000 this factor decreases to 0.998 or a change of 0.1%. in the A.C. to D.C. conversion ratio. It should be remembered that the absolute value of the A.C. to D.C. conversion ratio is not important. The value of this ratio is adjusted when the instrument is calibrated against the primary standard. The important factor is that this conversion ratio must remain constant for the thirty days between routine calibration checks.

3.4 AUDIO FILTER

The Audio Filter is a low pass L.C. filter designed to pass the average value of the half wave rectified signal from the A.C. to D.C. converter. The response of the filter is flat from D.C. to 20 cycles and is down 70 db at 30 cycles and retains this attenuation to beyond 20KC. This permits the filter to pass the amplitude variations in the A.C. signal without allowing the regulator to respond to the ripple in the rectified signal. The resistive pad at the input of the

filter isolates the rectifier circuit from the reactive impedance at the filter input.

3.5 D.C. REFERANCE AND SERVO AMPLIFIER

The D. C. Signal from the filter output is taken through a lead lag stabilization network Z101, for the servo and then compared with the precision D.C. reference by the 60 cycle contact modulator.

The D.C. reference is a silicon diode composed of two junctions back to back with matched temperature coefficients. This diode, Hoffman Semiconductor IN429, has a very low voltage coefficient of temperature in the zener region and the diode is mounted in a temperature controlled oven to further reduce its voltage fluctuations. The internal dynamic resistance of the diode is about 10 ohms. This means that a change of current of 0.6 ma will produce a change of 0.1% in the zener voltage of 6 volts. The zener current is derived from the regulated 150 volt supply through a resistance of 18 K ohms. A change of 11 volts in the 150 volt supply would therefore result in a change of 0.1% in the zener referance voltage.

The contact modulator G101, is a vibrating reed which mechanically switches the grid of the first stage of the servo amplifier alternately from the referance to the filter output at 60 cycles per second. This reed is driven at a phase angle of 90 degrees from the power line. The square wave output of the modulator is amplified and in the second stage of the servo amplifier converted to a sine wave by the filter A102, in the feed back, around the tube. The gain control at the output of the second stage provides for variations in tube gain so that the servo may always be operated with a minimum of dead space.. The sine wave which is proportional to the error in the A.C. voltage at the AVS 321 output, is further amplified and drives the servo motor to correct the error to zero. A servo motor and potentiometer are used to obtain the signal level control because this system does not introduce any distortion in the sine wave signal. The second section of the servo potentiometer is used to supply a rate feedback signal to the servo amplifier for stabalization.

3.6 POWER AMPLIFIER

The power amplifier section is a high feedback linear amplifier designed to deliver 30 watts to a matched load with a very minimum of distortion. It consists of a triode preamplifier followed by a grounded grid phase inverter V 704. V 705 is a push pull amplifier stage with negative feedback on its plates from the output stage. This is followed by V 705, a push pull cathode follower driver stage. The output stage is made up of four 5881's V707, V708, V709, and V710 operating in push pull parallel. The output transformer primary is divided into matched plate and cathode windings so that the stage is D.C. self balancing. The output is operated in Class AB-1 with current flowing in each half during approximately 300 degrees of the cycle. The output of the transformer is fed back to the cathode of the first stage, V703. The feed back in this loop is approximately 16 db.

The first stage plate is powered from a 105 volt supply regulated by the second half of V703. This supply has extremely low ripple and noise, the peak to peak value being less than 2mv. with zero signal on the amplifier.

3.7 POWER SUPPLY

The power supply consists of three major sections. First, the low plate supply is a source of 380 volts DC supplying two electronic regulators, (150 volt and 250 volt), and a 105 volt VR tube regulated reference supply. Second, a negative supply of 200 volts is the source of bias voltages in the AC Converter and Power Amplifier. Third, a high plate supply is the source of the 410 volt DC plate voltages on the power output tubes and through a dropping resistor supplies a 250 volt unregulated voltage to the AC Converter.

The 150 volt and 250 volt electronic regulators are of the series pass type and are nearly identicle in operation. The 250 volt pass tube is aided by another such tube located on the 60 cycle oscillator subassembly at the rear of the instrument.

In addition to these power sources, a 12 volt DC supply is provided to supply the input stages of both the AC Converter and Servo Amplifier with a DC heater voltage.

3.8 60 CYCLE INTERNAL OSCILLATOR

Because small amounts of 60 cycle hum in the system will cause the output voltage to vary at the beat frequency when operating within a few cycles of 60 or 120 cycles, the AVS-321 incorporates an internal, low distortion, 60 cycle oscillator. It is a Wien bridge oscillator, synchronized from the line frequency, phase shifted in such a manner so as to provide an in phase relationship between the output voltage and the 60 cycle system hum.

CALIBRATION

4.1 Standards

The Holt Instrument Laboratories AVS-321 Audio Voltage Standard is a working standard and should not be considered a primary standard of A. C. Voltage. It is designed and constructed with the utmost care and should have no trouble in maintaining its rated stability for the recommended calibration period of thirty days. However, with any instrument employing vacuum tubes a gradual change in tube characterisitics does cause a gradual shift in calibration as explained in the theory section of this manual.

Primary standards are those standards which may be reproduced anywhere in the world to a given degree of accuracy by using specified materials and construction. The Weston normal standard cell is the primary standard of voltage. To obtain a primary standard of A.C. Voltage, a transfer instrument must be used. This is an instrument which because of its basic principle of operation, will respond identically to A. C. or D. C. voltages having equal RMS magnitudes. The two instruments most commonly used for this purpose are the dynamometer and the thermocouple transfer voltmeter.

Holt Instrument Laboratories uses and recommends the Hermach Englehard Thermo transfer Volt-Ammeter for the calibration of the AVS-321

4.2 Calibration procedure:

The AVS-321 should be calibrated under carefully controlled laboratory conditions. Any attempt to adjust

the calibration casually in the factory or test lab will almost certainly result in operation outside the accuracy specifications of the instrument.

The following equipment is recommended for the calibration of this instrument:

Audio Oscillator	Holt Instrument A0.1 or Hewlett Packard 206 A
Distortion Analyzer	Hewlett Packard 330B
Oscilloscope	Tektronix 531
Transfer Standard	Hermach Englehard Transfer Volt Ammeter
Potentiometer	Leeds Northrup K3
Standard Cells	Eppley Model 100
Variac and line voltage meter, thermometer, Galvanometer, etc.	

PRELIMINARY:

Set the equipment up in a laboratory with reasonably clean line voltage. Excessive transients or radio frequency noise on the power line will make the calibration more difficult. Remove the AVS-321 from the cabinet and examine them for mechanical faults. Connect the units as shown in the first section of this manual, being sure that all grounds are properly connected. The use of a good earth ground is recommended. Connect the oscilloscope to the test points on the servo amplifier. Tp101 is the ground point, Tp102 is the servo error signal (ref. Fig. 6.8). Adjust the scope for 60 cycle sweep with line sync. The vertical gain should be set at 50 millivolts per cm.

With the equipment operating, move the servo gear with your finger. The error signal on the scope will increase as the servo is forced away from null, the phase of the error changing 180 degrees as the servo passes through null. At null, the error signal should not exceed 50 milli-volts peak to peak. The presence of larger error signals of 60 cycles or oscillator frequency usually indicates a faulty ground system. Monitor this error signal throughout the testing. A change in the peak voltage of 100 millivolts is approximately equal to a change of 0.1% in the output voltage of the AVS-321.

DISTORTION:

Check the distortion at the output of the AVS-321 at 290 volts and frequencies of 35 cycles, 1 kc and 10 Kc. The total distortion due to all parts of the system should be less than 0.25%. If necessary, adjust the distortion balance of the power amplifier on the 5881 chassis for minimum distortion.

DYNAMIC RESPONSE:

Slow the sweep of the scope to its minimum. Change the oscillator output 1 db by switching the attenuator switch on the HP 206a. The error signal on the scope should return to within 100 millivolts in less than 0.4 seconds.

VOLTAGE CALIBRATION:

Set the AVS-321 for 10 volt output at 1,000 cycles. The line voltage should be at 115 volts. Temperature 20 to 30 degrees centegrade. Allow at least 1 hour to warm up. Check the output carefully using the Transfer volt-ammeter. If

necessary, correct the voltage to 10 volts by adjustment of R104, the small DC reference trim pot inside the shield can at the top of the Servo amplifier chassis. Adjust the 290 volt range using R325, the trim pot at the top of the AC to DC Converter Chassis.

FREQUENCY RESPONSE:

Check the frequency response of the 10 volt range from 35 cycles to 10 kc. Small amounts of 60 cycle hum in the system will cause the output voltage to vary at the beat frequency when operating within a few cycles of 60 or 120 cycles. The peak to peak swing of these variations should be less than 0.1%. Operation exactly on 60 cycles or 120 cycles should be error free. Some of this variation may be due to the oscillator and some is contributed by intermodulation in the power amplifier. If necessary, adjust the low frequency response from 200 cycles down by adjusting the value of C311 and R326. The high frequency response from 4 Kc to 10 Kc is adjusted by trimming C307 and R307. This network is found on the AC converter board in shunt with R301.

The frequency response should now be flat from the low frequency end to 10 Kc. A small compensating network has been inserted at the factory to correct each 10 volt step from 10 volts through 290 volts. These are located in the attenuator enclosure as shown in Fig. 6.3, page 6-3. They should not require readjustment except when a resistor in the attenuator is replaced.

SECTION 5
MAINTENANCE

5-1 OVERHAUL AND FACTORY ADJUSTMENT PROCEDURE

Prior to shipment, the AVS-321 is accurately calibrated under carefully controlled laboratory conditions. Naturally the manufacturer recommends that future calibrations be similarly conducted. Any attempt to casually adjust the calibration will most certainly result in operation outside of the accuracy specifications of the instrument.

The following equipment is recommended for the calibration procedure:

Audio Oscillator	Holt Instrument Labs. Model A0.1
Distortion Analyzer ..	Hewlett Packard Model 330B
Oscilloscope	Tektronix Type 531
Transfer Standard	Hermach-Englehard Transfer volt-ammeter
Potentiometer	Leeds Northrup K2 or K3
	Otto Wolff KF-4 or KF-5
Standard Cells	Eppley Model 100
Vacuum Tube Voltmeter.	11 meg ohm input resistance
	3% full scale accuracy
Wheatstone Bridge	Otto Wolff 944

Variac, Line voltage meter, thermometer, Galvonometer, etc.

VISUAL INSPECTION

With power off, visually check for shorts, poor solder joints, loose or broken wires, missing or burnt components, etc.

MINIMIZE SERVO MOTOR AND POTENTIOMETER MECHANICAL FRICTION

The maximum motor, gear and pot friction is 3 inch ounces on the potentiometer shaft. Should this be excessive, remove the motor gear and check the motor and pot independently. If neither seems excessive, the gear mesh itself can be adjusted by loosening the set screw in the eccentric bearing on the pot shaft. By slowly turning the eccentric, the degree of gear mesh can be optimized to give quiet, close mesh with a minimum of friction. Reset the set screw after completing the adjustment.

SET THE .01 VOLT DECADE VARIABLE RESISTOR

Connect an ohmmeter on the 10,000 ohm range across the variable resistor, (R-644). Set the stop so that the resistance at the clockwise extremity is zero and 100 ohms at the counter-clockwise extremity and there are no discontinuities between the extremes. Loosen the knob set screw and turn the dial to zero with the resistor set at its clockwise extremity.

BRIDGING PRECISION RESISTORS

Ground the point between R-301 and C-304 on the AC Converter subassembly. Disconnect the purple and white lead from the wiper of S-600-C in the attenuator. Connect the bridge between this point on S-600-C and ground. See figure 5-1.1 for dial settings and corresponding resistances. All resistors should be within three hundredths of a percent of the indicated value.

To bridge the precision resistors on the AC

HOLT INSTRUMENT LABORATORIES

PRECISION RESISTOR VALUES AVS-321

A.C. CONVERTER

R-324	1,106
R-301	10,000
R-302	10,000
R-320	10,000
R-321	10,000
R-322	435
R-401	100,000
R-402	50,000

ATTENUATER

RANGE	RESISTANCE	RANGE	RESISTANCE
1.0	Adjust R-325 for 1,000 ohms	20.0	20,000
1.1	1,100.0	30.0	30,000
1.2	1,200.0	40.0	40,000
1.3	1,300.0	50.0	50,000
1.4	1,400.0	60.0	60,000
1.5	1,500.0	70.0	70,000
1.6	1,600.0	80.0	80,000
1.7	1,700.0	90.0	90,000
1.8	1,800.0	100.0	100,000
1.9	1,900.0	110.0	110,000
2.0	2,000.0	200.0	200,000
3.0	3,000.0	300.0	300,000
4.0	4,000.0	400.0	400,000
5.0	5,000.0	500.0	500,000
6.0	6,000.0	600.0	600,000
7.0	7,000.0	700.0	700,000
8.0	8,000.0	800.0	800,000
9.0	9,000.0	900.0	900,000
10.0	10,000.0	999.9	999,900
11.0	11,000.0		

Figure 5.1.1

Converter subassembly simply remove all the jumpers soldered between test points throughout the circuit. Also disconnect AC Converter from the Attenuater. This procedure isolates all circuit segments containing precision resistors allowing them to be accurately measured. Again refer to figure 5-1.1 for proper value of each resistor.

OPERATIONAL CHECK ON POWER SUPPLIES

Plate and Bias Supplies

With a VTVM read the following test points. At the same time observe the ripple voltage with the oscilloscope and compare to the waveforms Figures 5.7 through 5.11. The regulating ability of the 150 and 250 volt electronic regulators can be observed by lowering and then raising the line variac ten percent above and below the 115 volt operating point while monitoring the regulated voltages for loss of regulation. At 115 volt line voltage, check the following DC voltages supplies:

C-201 B ..... 385 volts DC
V-202 pin 1 ..... 105 volts DC
C-203 B .....Neg. 200 volts DC
C-207 B ..... 410 volts DC
PL-203 pin 2 ..... 150 volts DC
PL-202 pin 1 ..... 250 volts DC
C-206 Terminal ..... + 5 volts DC
C-206 Can ..... - 5 volts DC

The damping voltage is measured between R-280 and R-249 on the underside of the AVS-321 chassis. Proper

voltage lies between 12.0 and 14.0 volts DC.

READ ALL DC VOLTAGES

With a VTVM read all DC tube voltages indicated on DC voltage charts Fig. 5.1 through 5.6.

CENTER FRONT PANEL METER FOR ONE VOLT RMS

Connect a low distortion oscillator to the input terminals and monitor the input signal magnitude with a reliable meter. Set the oscillator for 1000 cycles and one volt RMS. The front panel meter on the AVS-321 should read one volt as well. The meter can be adjusted by turning the screw adjustment on the face of the meter movement.

ROUGH CHECK THE OUTPUT VOLTAGE

Connect an AC meter capable of reading voltages up through 1000 volts, to the output terminals of the instrument. With one volt input and 1000 cycles, select an output of one volt and read the output. Increase each decade switch in turn constantly watching the output. This check merely verifies the proper transformer and attenuator connections and in no way is a calibration procedure.

ROTATE FAN FOR MINIMUM 60 CYCLE IN THE ERROR SIGNAL

Connect the oscilloscope to the error signal test points on the Servo Amplifier subassembly. TP 101 is the ground point and TP 102 is the servo error signal. Adjust the scope for a 60 cycle sweep with line sync. The verticle gain is set at 50 millivolts per centimeter.

With the instrument operating, move the servo gear either direction with your finger. The error signal will increase as the servo is moved from its null point, the phase of the error changing 180 degrees as the servo passes through null At null, the error signal should not exceed 50 millivolts. The presence of a larger error indicates the presence of 60 cycle inductive pickup. The induced 60 cycle in all probability is from the fan motor. Since the motor is of the hysteresis type, direct shielding will affect its own operation. Therefore the manufacturer shields the more sensitive portions of the Servo Amplifier circuitry. The chopper is constructed with an internal conetic shield and the input tube V101 is provided with a conetic insert inside the tube shield. Be sure this insert is always in place.

To further reduce induction, the fan motor is mounted so that loosening four bolts allows the entire mount to be rotated approximately 180 degrees or any portion thereof. Loosen the described bolts and rotate the fan mount observing the error signal. The optimum location is that position where the error signal is the flattest.

PERFORM OPERATIONAL CHECKS ON THE SERVO AMPLIFIER AND AC CONVERTER.

If the DC voltages are normal throughout both the Servo Amplifier and the AC Converter, placing the instrument in operate should cause the servo to seek its null point. If some malfunction still exists, use the following procedure. Turn the Servo Amplifier gain (R118)

fully counter-clockwise.

Check to see if one volt RMS is being fed to the input stage of the converter. With the oscilloscope, check the signal after either CR 301 or CR 302. The signal should be 28 to 33 volts peak to peak, each 180 degrees displaced from the other. The output of the filter as fed to the Servo Amplifier should be flat with a DC level of 3 to 4 volts depending on the position of the servo potentiometer.

If everything is operational up to this point, remove the chopper from its socket. Trace the filter output from the Converter board through Z 102 to pin 2 of the chopper socket. With a VTVM read the zener reference voltage at pin 8 of the reference oven (Z 101). The proper voltage is between 6 and 7 volts DC. Read the reference voltage at pin 4 of the chopper socket. Its value depends on the setting of R-104 but is between 3 and 4 volts DC. Reinsert the chopper and replace the cap. Be certain the chopper is being driven at 60 cycles and is properly sampling by observing its output at pin 3 of the chopper socket. The chopper output undergoes a voltage Gain of approximately 1200 to the error signal test point, TP 102. If this gain is normal increase the servo gain adjustment (R 118) to the fully clockwise position. The servo should seek its null point and rapidly jitter when it gets there. Decrease the gain until the jittering stops.

Should the Servo still fail to operate properly, disconnect the arm of the servo gain pot and connect a 60

cycle sinousoidal signal of about fifteen millivolts to pin 2 of V 102. With the motor rotor blocked, the transformer secondary voltage should be about 9 volts peak to peak and appear as a good sine wave. With the motor rotor free, increase the signal at pin 2 from zero to fifteen millivolts. If the motor does not start to turn or it takes more than fifteen millivolts to start it, check the motor, gears and potentiometer for excessive mechanical friction. Let the input frequency drift one or two cycles above or below the line frequency. The servo motor should run first one way and then the other. When the motor is running the secondary of the transformer should rise to about 90 volts peak to peak.

BALANCE ATTENUATOR .1 VOLT DECADE

Remove R 650 and R 651 from attenuator S-603-C, and in their place put a 50,000 ohm variable resistor. With the instrument set for 1.1 volts output and a 1000 cycle input, turn the instrument to operate. Vary the amplitude of the input signal at the oscillator observing the front panel meter. Make a mental note of the needle positions at the instant the servo pot reaches full rotation one way, and then the other. The two extremes should include the one volt RMS point. Reset the output voltage for 9.1 volts and repeat procedure. Do the same at outputs of 1.9 and 9.9 volts. If necessary adjust the potentiometer replacing R 650 and R 651 so that servo extremes include the 1 volt RMS point on all of the above mentioned ranges.

When a satisfactory setting has been achieved, measure the resistance of the pot and install a similar fixed resistor.

READ HUM LEVEL

Turn the servo gain completely counter-clockwise. With a 1000 cycle, 1 volt RMS input to the instrument, select 300 volts output. Using the Hewlett Packard 330B meter, vary the input until exactly 300 volts is read. Now attenuate the input signal to zero. Read the output, which is all hum, and it should be at least 60 db below the 300 volts.

READ AND MINIMIZE HARMONIC DISTORTION

With the instrument operating at 10 volts nominal output, connect the Hewlett Packard 330B. Read the distortion at a number of frequencies between 35 cycles and 10,000 cycles. The total harmonic distortion should be less than .15% added to oscillator distortion. If necessary, adjust the distortion control on the Power Amplifier subassembly.

READ FEEDBACK LEVEL

With no signal applied and the servo gain turned completely counterclockwise, disconnect the feedback lead in the Power Amplifier. Select 10 volts output and at various frequencies from 35 to 10,000 cycles gradually increase input level until output reaches 10 volts. (Caution: With no feedback the gain of the amplifier is

considerably greater. As a result, less than one volt input will produce the desired output. Never exceed the selected output.) Connect the feedback loop and read the new output voltage. The desirable level of attenuation is between 17 and 19 db. If necessary adjust feedback components to achieve this level.

CHECK AMPLIFIER STABILITY

Connect the oscilloscope to the 250 volt regulated supply. Set the scope sensitivity for about one volt per centimeter. Rapidly and repeatedly switch the operate-standby switch back and forth, observing the oscilloscope for any tendency toward sustained high frequency oscillations. Reconnect the oscilloscope to the output terminals and repeat the above procedure. The presence of oscillations are an indication of Amplifier instability sometimes due to excessive feedback, or an incorrect adjustment of C 708.

SET AND COMPENSATE 1 VOLT RANGE FOR HIGH FREQUENCY

To properly accomplish 1 volt calibration, a special one volt thermocouple transfer device is used in the factory calibration. The one volt level is set with a 1000 cycle input signal, by adjusting the reference trim pot (R 104) so that the output exactly equals 1.0000 volts. The frequency response is then checked from 1000 cycles to 10,000 cycles. If at any point the output voltage varies in excess of .1%, the high frequency compensation can be adjusted. (R307, C307). These components have little or

no effect on the output at 1000 cycles.

SET AND COMPENSATE THE 10 VOLT RANGE FOR LOW FREQUENCY

Connect the output to the Hermach Englehard transfer standard with a 1000 cycle signal input. Set the output level for exactly 200.00 volts with the trim pot, R 325. Vary the input frequency from 1000 cycles to 35 cycles observing output level. If the output varies out of specifications, adjust the low frequency compensation (R 323, R 326, C 311). The low frequency compensation, although set at 200 volts output, holds for any output voltage. The adjustment of R 325 sets the 1000 cycle level of all voltages from 1.1 volts to 1000 volts. These voltages are controlled by the ratios of the precision attenuator resistors and should be within ± 0.05% of the attenuator setting at 1000 cycles.

COMPENSATE ALL RANGES FOR HIGH FREQUENCY

Using the Hermach Englehard transfer standard and the foregoing procedures, observe the frequency response from 1000 cycles to 10,000 cycles at every range from 10 volts through 290 volts in ten volt increments. If necessary, adjust the individual compensation provided for each range. See Figure 6.3.

ADJUST THE FREQUENCY, LEVEL, AND DISTROTION OF THE 60 CYCLE INTERNAL OSCILLATOR

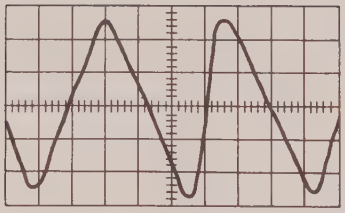
Connect the oscilloscope to pin 7 of V 210. Set the sweep for 60 cycle line sync. Adjust the frequency control

(R 262). With the Hermach Englehard connected to the output and the instrument operating at 10 volts from the internal oscillator, adjust until the output reaches 10.000 volts. If the oscillator becomes unstable before this point is achieved, it will be necessary to change the phase of the synchronizing voltage. A 90 degree shift is attained by interchanging R 281 and C 266. A 180 degree phase shift is possible by reversing the V 210 filament winding at the transformer.

Adjust the level until the front panel meter reads exactly one volt RMS. Then adjust the distortion control for minimum harmonic distortion at the output terminals. Since the level and distortion controls are in series there is some interaction. Subsequently it may be necessary to adjust each alternately until the optimum is reached.

POWER SUPPLY

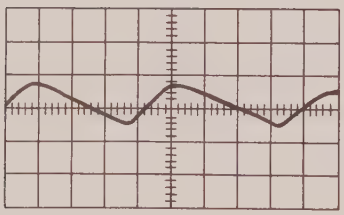
WAVEFORMS



C 201 B

0.5 V PER DIV.

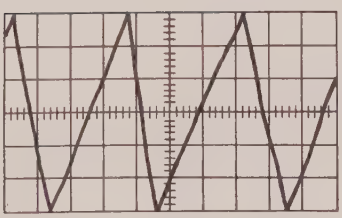
2 MILLI SEC PER DIV.



V 202 PIN 1

.01 V PER DIV.

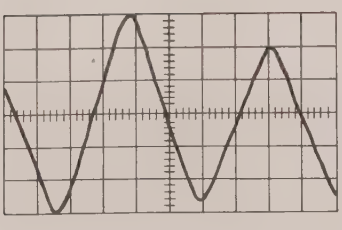
2 MILLI SEC PER DIV.



C 203 B

0.2 V PER DIV.

5 MILLI PER DIV.



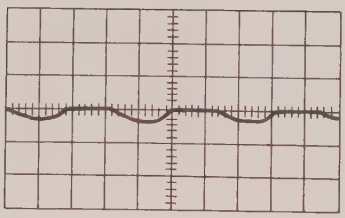
C 207 B

0.5 V PER DIV.

2 MILLI SEC PER DIV.

150 VOLT REGULATOR

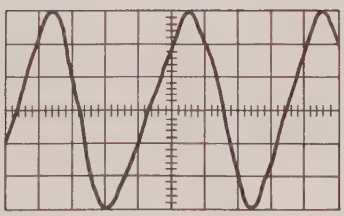
WAVEFORMS



PIN 2 PL 203

0.01 V PER DIV.

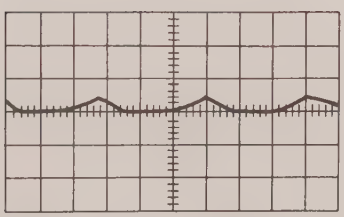
5 MILLI SEC PER DIV.



PIN 6 V 207

0.02 V PER DIV.

2 MILLI SEC PER DIV.



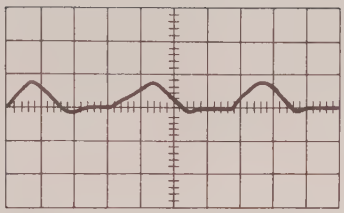
PIN 2 V 208

0.01 V PER DIV.

5 MILLI SEC PER DIV.

250 VOLT REGULATOR

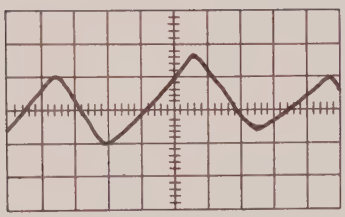
WAVEFORMS



PL 202 PIN 1

0.01 V PER DIV.

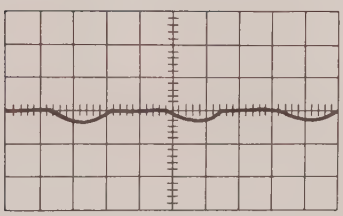
5 MILLI SEC PER DIV.



V 204 Pin 6

0.05 V PER DIV.

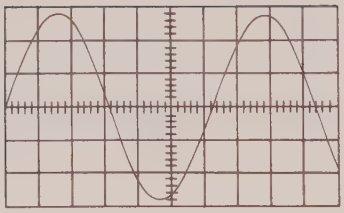
2 MILLI SEC PER DIV.



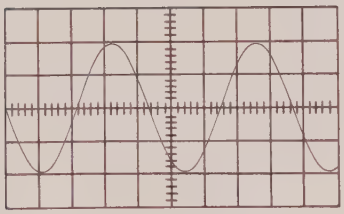
V 205 PIN 2

0.01 V. PER DIV.

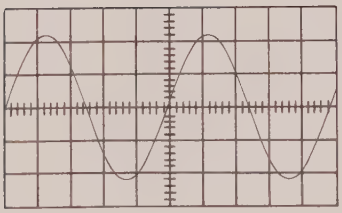
5 MILLI SEC PER DIV.



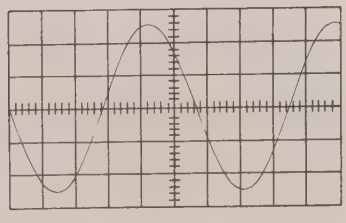
V-703 Pin 7
.15 volts Peak to Peak
Signal Frequency
* Taken with a low capacity probe.



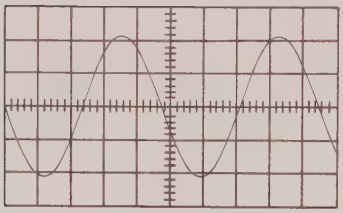
V-703 Pin 6
Amplitude between 2 and 4 volts P. to P. dependent on feedback signal frequency
* Taken with a low capacity probe.



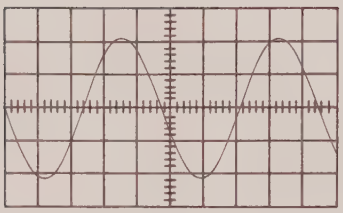
V-704 Pin 6
2.2 volts Peak to Peak
Signal Frequency
* Taken with a low capacity probe



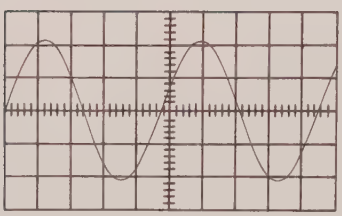
V-705 Pin 6
250 Volts Peak to Peak
Signal Frequency



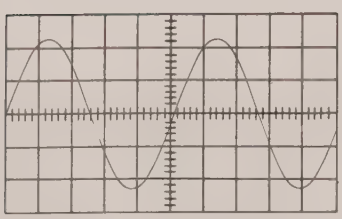
V-706 Pin 8
240 Volts Peak to Peak
Signal Frequency



V-709 Pin 8
V-710 Pin 8
215 Volts Peak to Peak
Signal Frequency

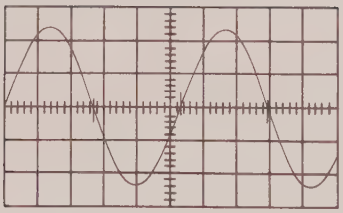


V-709 Pin 3
V-710 Pin 3
215 Volts Peak to Peak
Signal Frequency

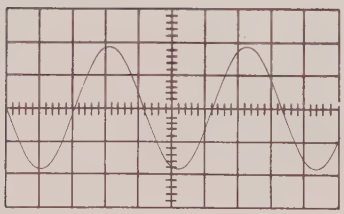


V-703 Pin 8
.9 Volt Peak to Peak
Signal Frequency

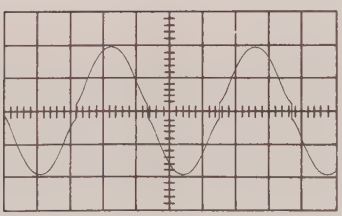
AC - DC CONVERTER WAVEFORMS



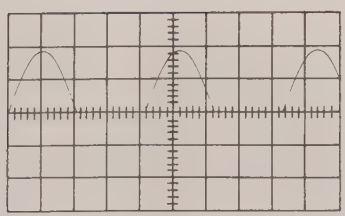
V-302 Pin 5
1.4 Volts Peak to Peak
Signal Frequency
* Note spikes at zero crossover



V-303 Pin 5
75 volts Peak to Peak
Signal Frequency
* Note Discontinuities at
zero crossover



V-304 Pins 3 & 6
76 volts Peak to Peak
Signal Frequency
* Note zero jumps.

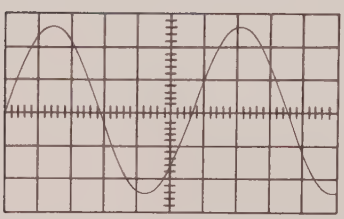


T. P. 306
33 volts Peak to Peak
Signal Frequency

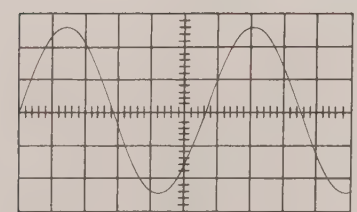
The following two waveforms are taken under test conditions. Normally the amplitude is a function of error amplitude and the wave form is actually distorted. However, it may become necessary to determine the operational capabilities of this stage. To do so follow this test procedure:

1. Unit in Standby
2. Chopper removed from its socket
3. A 10 millivolt peak to peak, 60 cycle signal applied at Pin 2 of V-101.

Following are the wave forms:



V-101 Pin 1
.44 Volts Peak to Peak
60 cycles per sec.



V-101 Pin 6
9 Volts Peak to Peak
60 cycles per sec.

DC VOLTAGES

AC to DC CONVERTER

Fig. 5.1

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V301	6136	-2.5	0	0	-5.0	+110	+150	0		
V302	6AU6	-2.0	0	0	6.3 VAC	+ 85	+150	0		
V303	6AU6	-2.0	0	0	6.3 VAC	+110	+150	0		
V304	5687	+245	+110	+115	6.3 VAC	6.3 VAC	+115	+110	0	+245

D. C. Voltages

Servo Amplifier

Fig. 5.2

TUBE	TYPE	PIN NUMBER								
		1	2	3	4	5	6	7	8	9
V101	12AX7	+60	-.68	0	0	0	+110	0	+1.4	+5VDC
V102	12AX7	+78	0	+1.1	6.3VAC	6.3VAC	+75	0	+1.1	0
V103	6AQ5	0	+17	0	6.3VAC	+290	+300	0		
V104	6AQ5	0	+17	0	6.3VAC	+290	+300	0		

DC VOLTAGES

PRE-AMPLIFIER

Fig. 5.3

TUBE	TYPE	Pin Number								
		1	2	3	4	5	6	7	8	9
V701	6AB4	+245	NC	6.3VAC*	0*	+245	0	+4.3		
V702	OB2	NC	NC	NC	NC	0	NC	-105		
V703	12AX7	+109	-.7	0	0*	0*	+97	0	+1.3	6.3VAC*
V704	12AU7	+215	-7**	+100	0*	0*	+206	- 7 **	+100	6.3VAC*
V705	12AU7	+300	0	+17	0*	0*	300	0	+ 17	6.3VAC*
V706	12AX7	+410	-33	-32	0*	0*	+410	-33	-32	6.3VAC*

* Measured from Pin 4 V703

** Measured from Pin 3 V703

DC VOLTAGES

POWER AMPLIFIER

Fig. 5.4

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V707	5881	NC	4.5	410	405	- 32	NC	4.5	3.5*	
V708	5881	NC	4.5	410	405	- 32	NC	4.5	3.5*	
V709	5881	NC	4.5	410	405	- 32	NC	4.5	3.5*	
V710	5881	NC	4.5	410	405	- 32	NC	4.5	3.5*	

* Measured across 50 ohm cathode resistor with signal input.

DC VOLTAGES

+ 150 and + 250 REGULATORS

Fig. 5.5

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V 205	12AX7	+83	-.12	+.67	0	0	+135	0	0	6.3VAC
V 212	12AV7	+95	-3.5	0	0	0	+137	-3.5	0	6.3VAC
V 203	12AV7	+270	+137 + .8 *	+137 +1.4*	0	0	+270	+137 + .8*	+137 +1.4*	6.3VAC
V209	12AV7	260	+137 + .8 *	+137 +1.4*	0	0	260	+137 + .8*	+137 +1.4*	6.3VAC
V 208	12AX7	+83	-1.3**	-19	0	0	+135	-1.3***	-19	6.3VAC
V 213	12AV7	+95	-3.5	0	0	0	+137	-3.5	0	6.3VAC
V 206	12AV7	+270	+43 -1.5**	+46 +1.4**	0	0	+270	+43	+46 +1.4**	6.3VAC

NOTE: All measured from Pin 3, V-212 or V-213 except those listed below:

* Measured from Pin 6 V205

** Measured from Pin 2 PL203

*** Measured from Pin 3 V208

DC VOLTAGES

60 CYCLE OSCILLATOR

Fig. 5.6

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V210	6AV6	3.8	7.1			119	148	7.1		
V211	5687	235	120	122			4.5			122

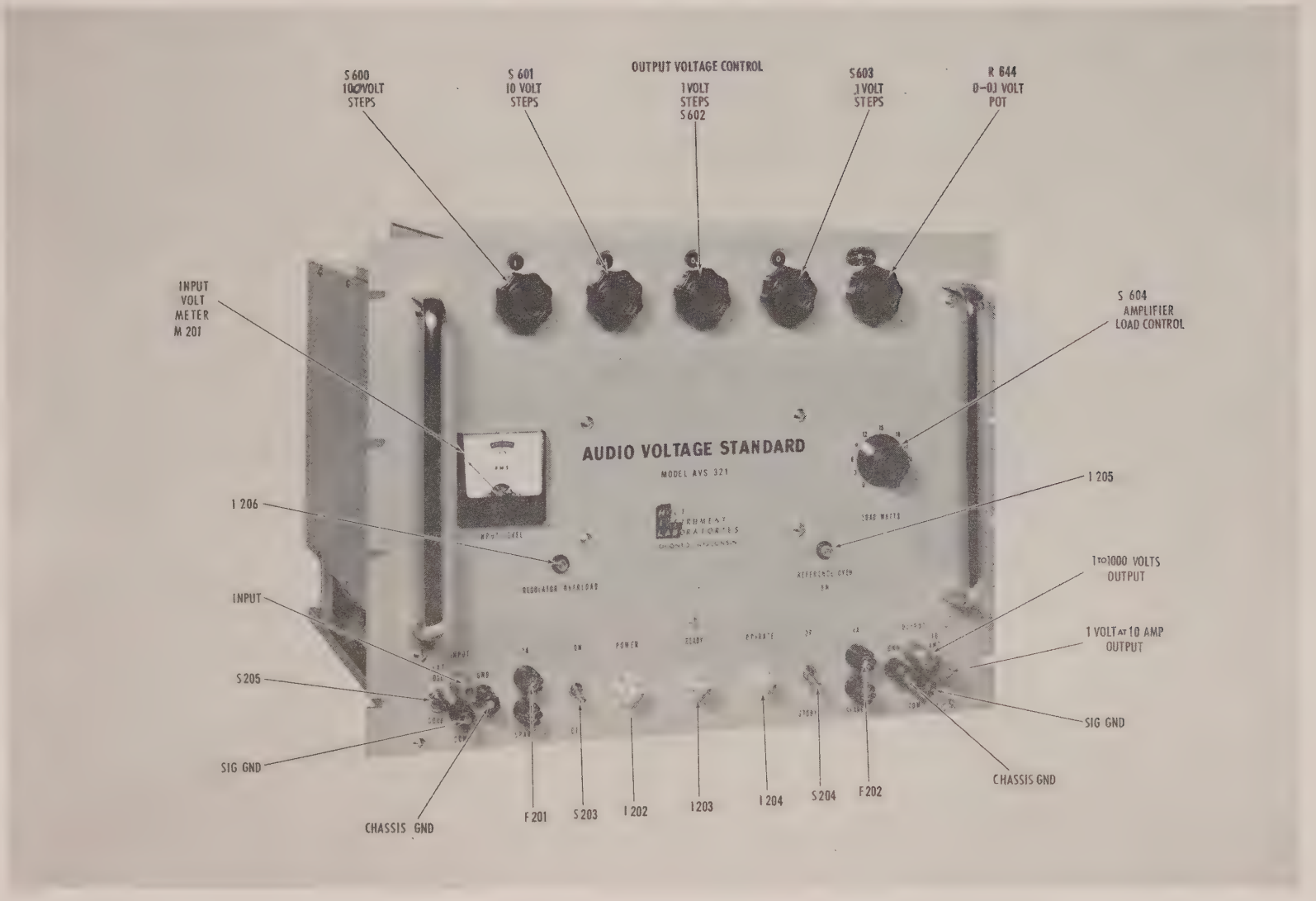
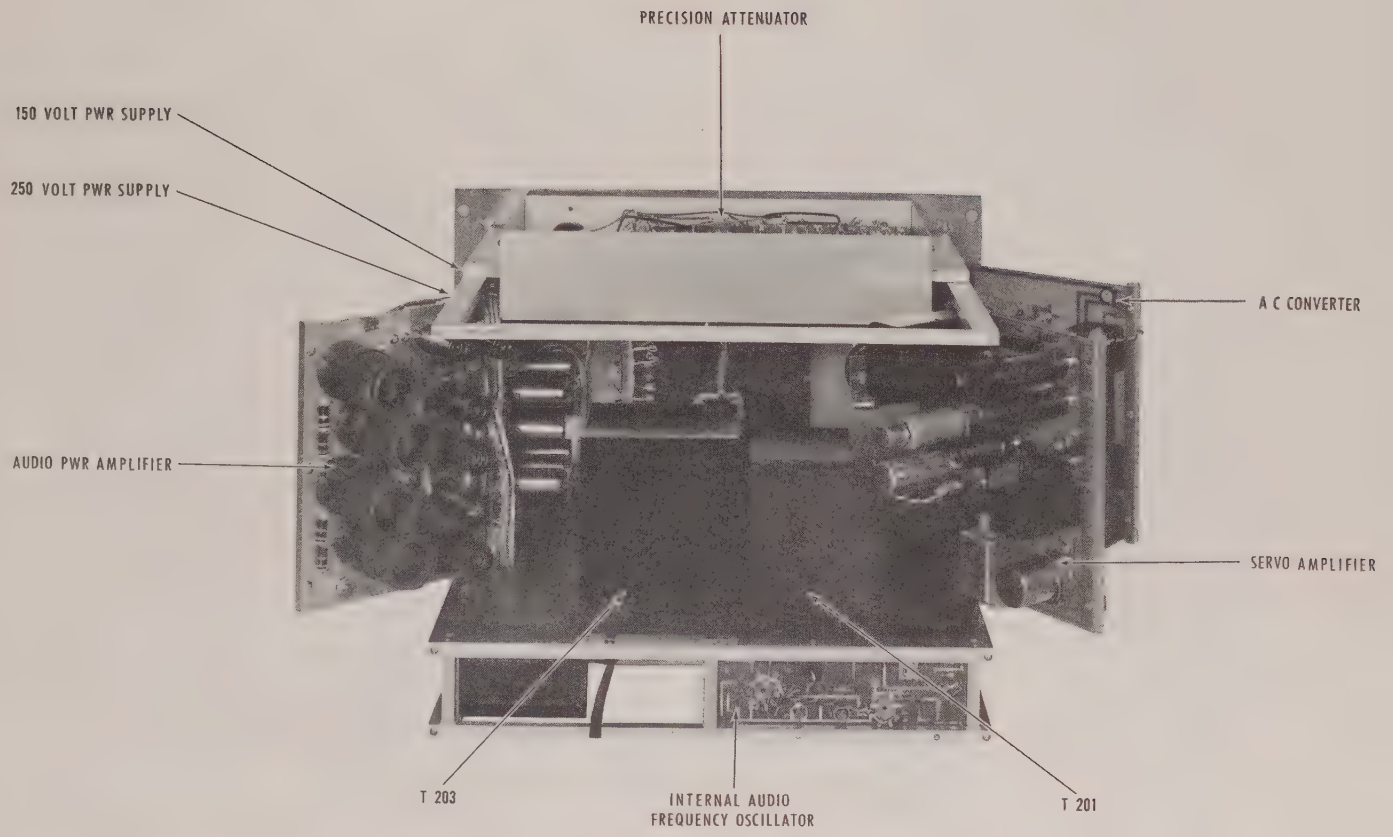
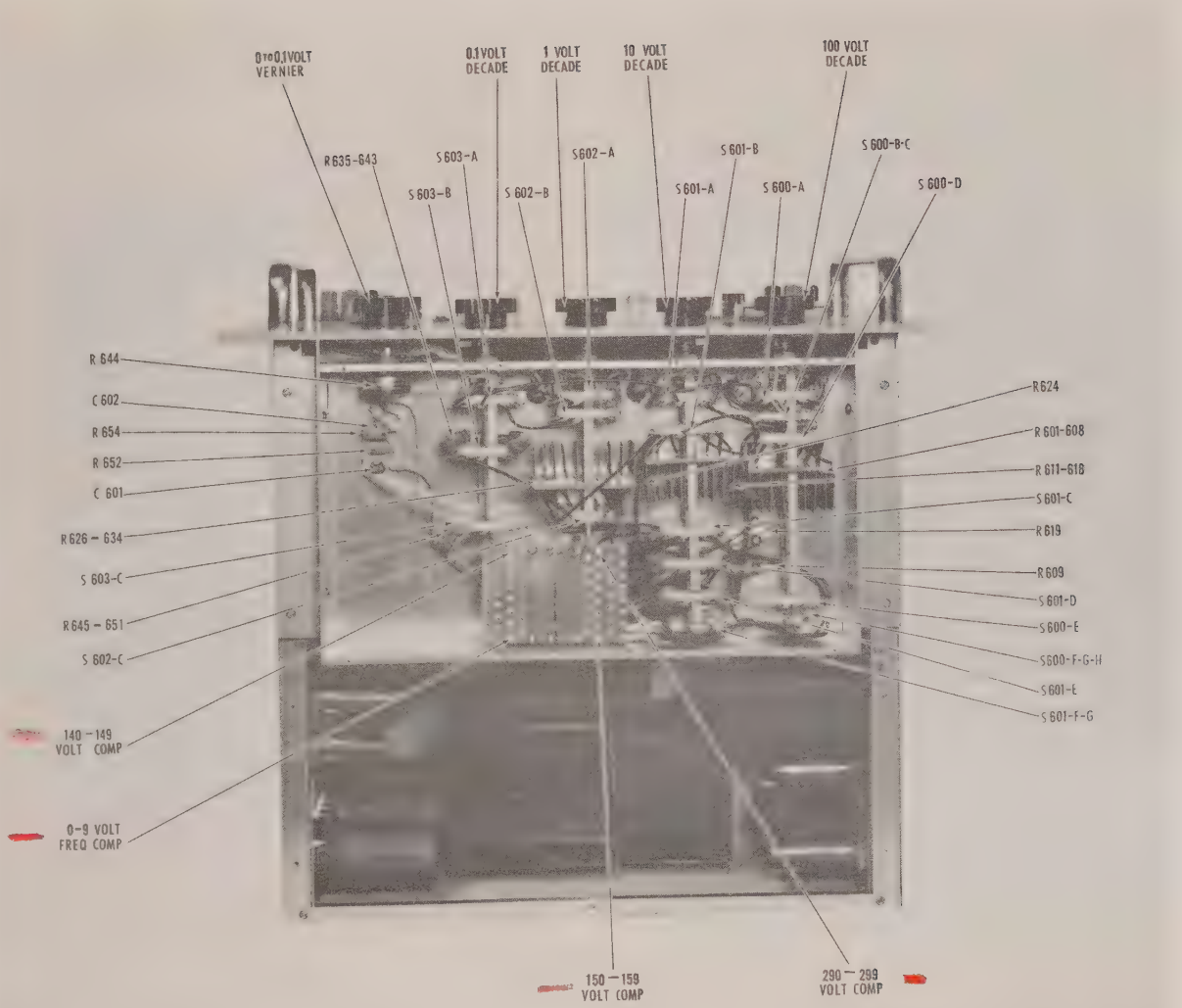

S 600
100 VOLT
STEPS
S 601
10 VOLT
STEPS
OUTPUT VOLTAGE CONTROL
1 VOLT
STEPS
S 602
S 603
.1 VOLT
STEPS
R 644
0-.1 VOLT
POT
INPUT
VOLT
METER
M 201
S 604
AMPLIFIER
LOAD CONTROL
AUDIO VOLTAGE STANDARD
MODEL AVS 321
I 205
I 206
1 TO 1000 VOLTS
OUTPUT
INPUT
1 VOLT AT 10 AMP
OUTPUT
S 205
SIG GND
SIG GND
CHASSIS GND
CHASSIS GND
F 201
S 203
I 202
I 203
I 204
S 204
F 202

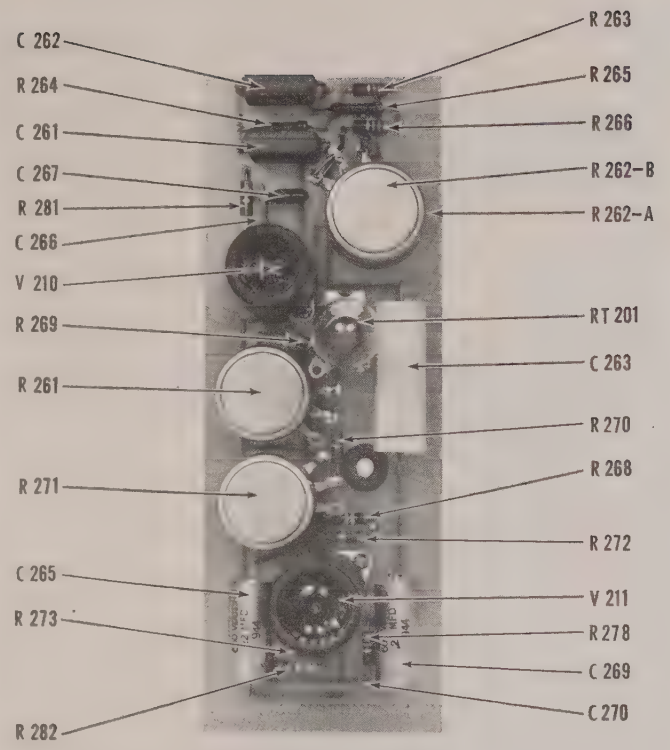
FIG. 6.1



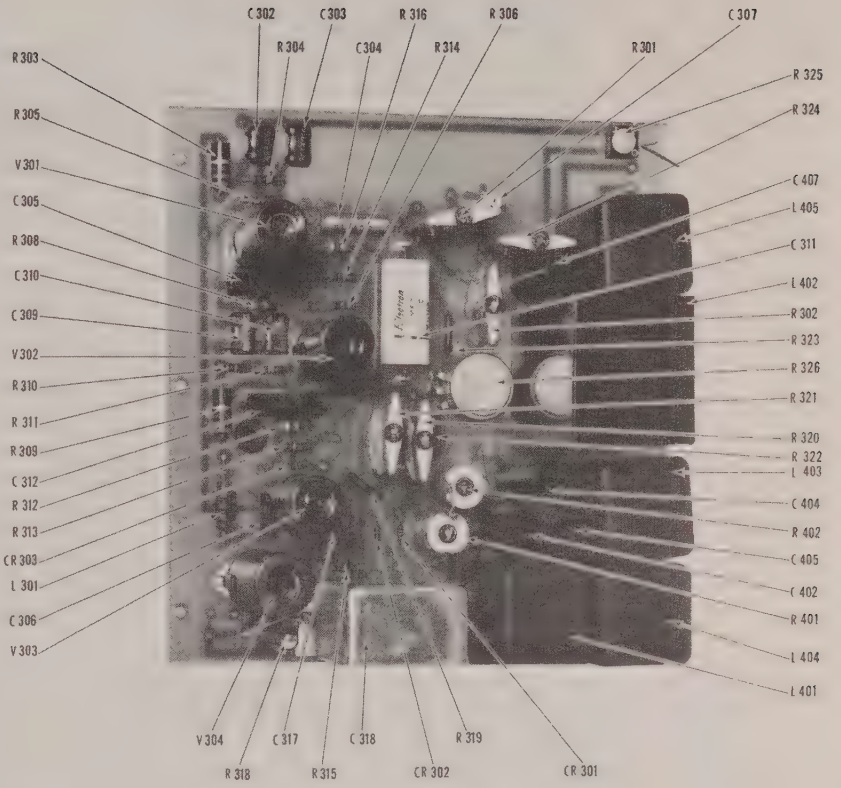
REAR VIEW
FIGURE 6.2



TOP VIEW
FIG. 6.3



60 Cycle
Oscillator
Fig. 6.4



AC - DC Converter
Fig. 6.5

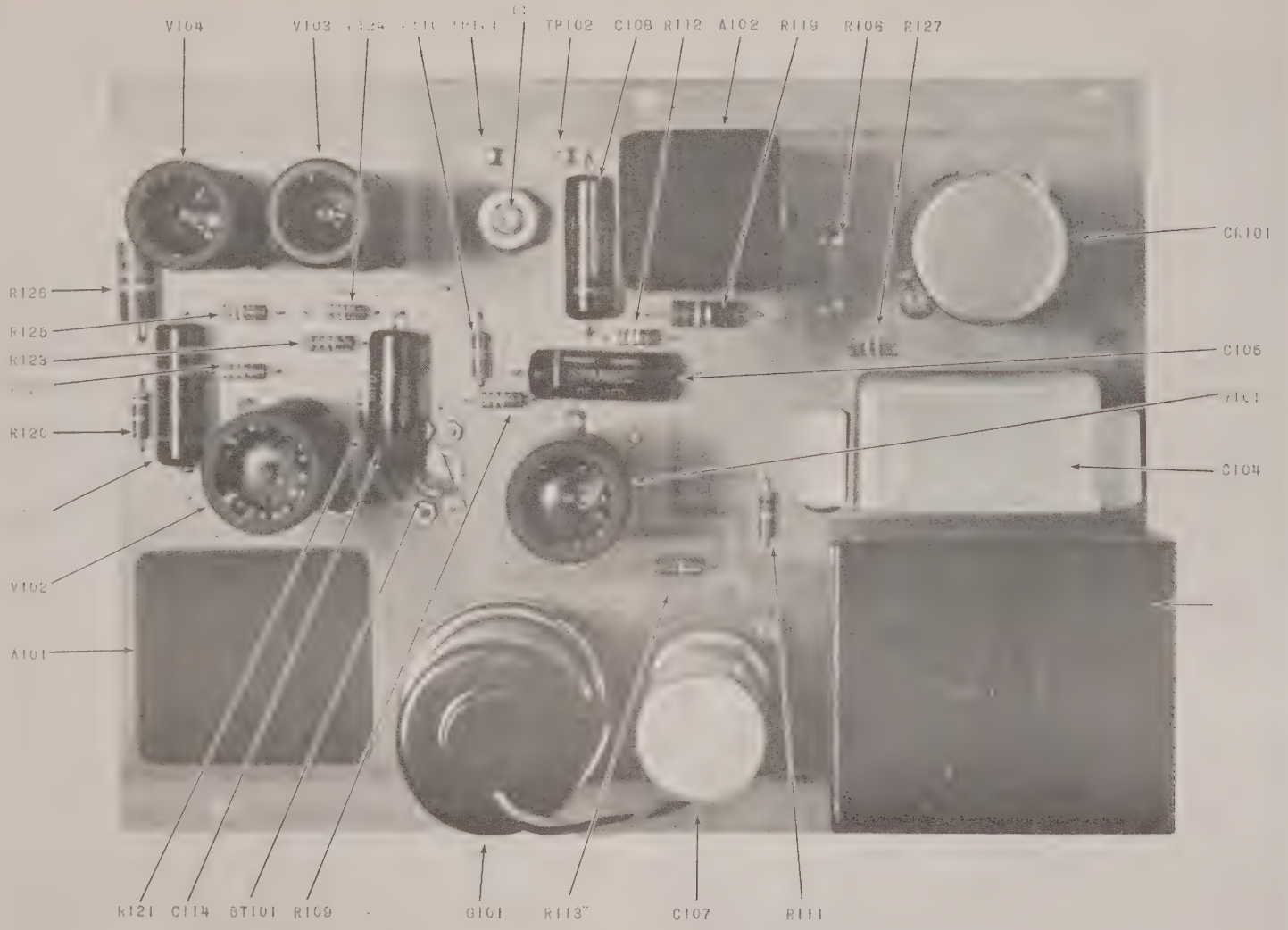


FIG. 6.8
SERVO AMPLIFIER

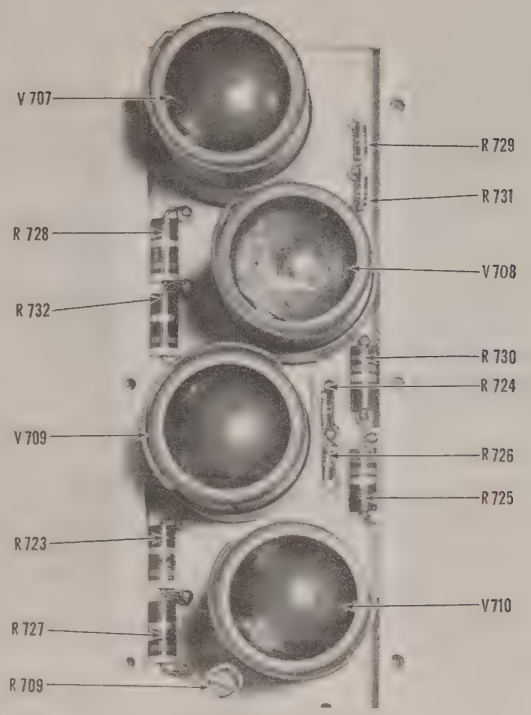

V 707
R 729
R 731
R 728
V 708
R 732
R 730
R 724
V 709
R 726
R 725
R 723
V 710
R 727
R 709

FIG. 6.7

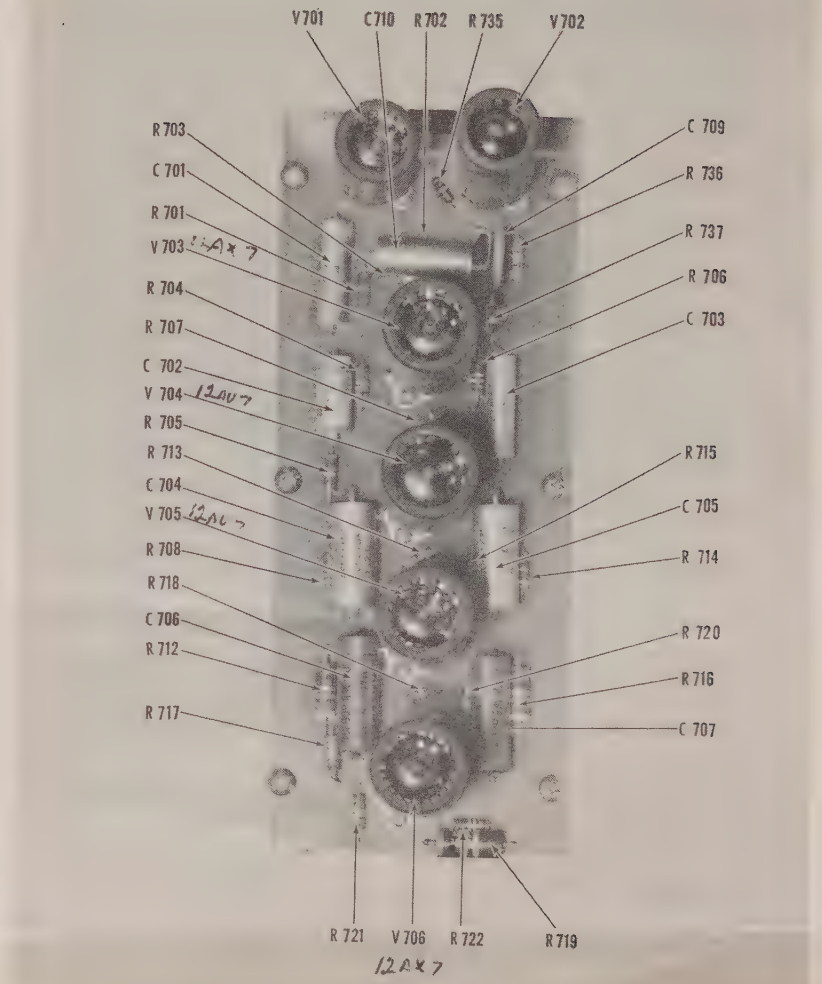

V 701
C 710
R 702
R 735
V 702
R 703
C 709
C 701
R 736
R 701
R 737
V 703 12AX7
R 706
R 704
C 703
R 707
C 702
V 704 12AU7
R 705
R 715
R 713
C 705
C 704
V 705 12AU7
R 714
R 708
R 718
C 706
R 720
R 712
R 716
R 717
C 707
R 721
V 706
R 722
R 719
12AX7

FIG. 6.8

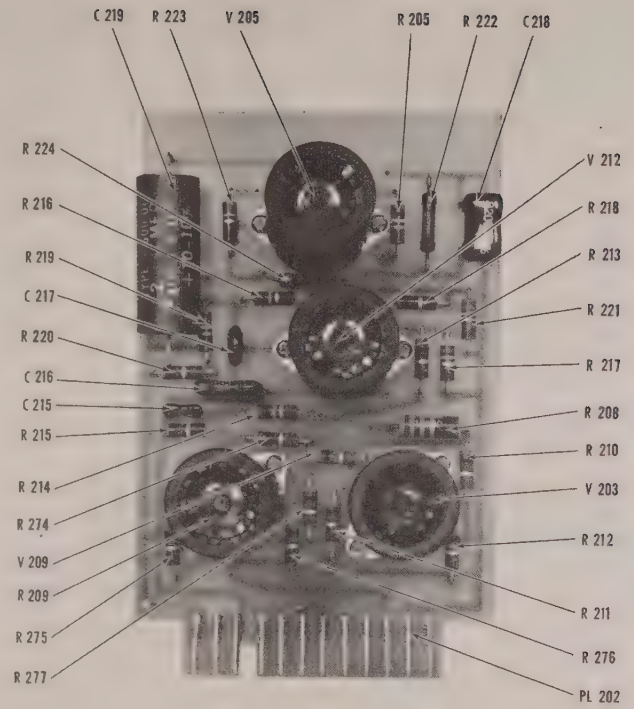


FIG. 6.10

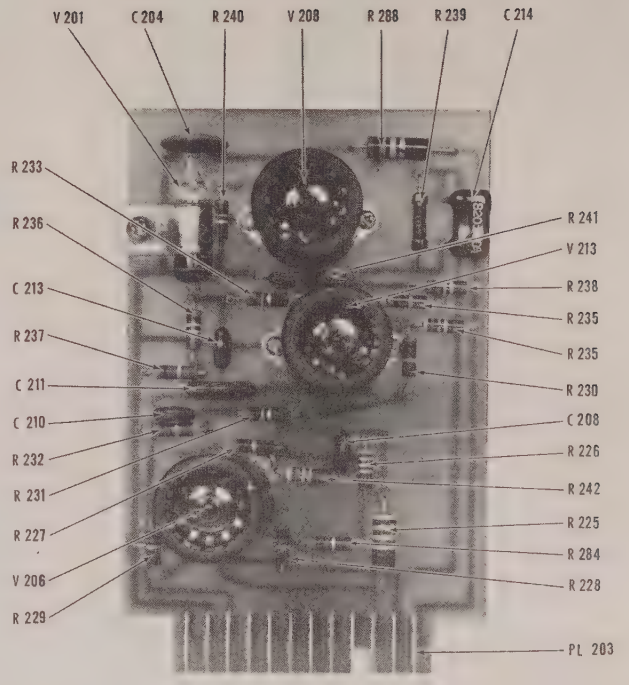


FIG. 6.9

ELECTRONICS PARTS REFERENCE DESIGNATIONS

CP	Adapter, connector
A	Amplifier (other than rotating)
E	Antenna; aerial
A	Assembly
AT	Attenuator
DS	Audible signaling device
T	Autotransformer
BY	Battery
E	Bimetallic strip
TB	Block, connecting
B	Blower; fan; motor; prime mover
TB	Board, terminal
CB	Breaker, circuit
DS	Buzzer
W	Cable
C	Capacitor
E	Cell, Aluminum or electrolytic
V	Cell, light-sensitive, photo-emissive, or photo conductive
N	Chart
L	Choke
CB	Circuit breaker
M	Clock
HY	Coil, hybrid
L	Coil, induction, loading, relay operating, retardation, tuning
J	Connector, receptacle, electrical (with male, female, or male & female contacts and designed to be mounted on a bulkhead, wall, chassis or panel)
P	Connector, plug, electrical (with male, female, or male & female contacts, constructed to be affixed to the end of a cable, conduit, co-axial line, cord or wire)
K	Contactor (electrically operated
S	Contactor (mechanically or thermally operated)
M	Counter (indicating device)
CR	Crystal detector
CR	Crystal diode
Y	Crystal, piezoelectric
CR	Crystal unit
S	Cutout, thermal
CR	Detector, crystal
DS	Device, indicating (except meter or thermometer)
V	Electron tube
B	Fan
FL	Filter
DS	Flasher
F	Fuse
X	Fuseholder (see 5.6.1)
H	Hardware; bolts; nuts; screws
HR	Heater (element for Thermostat, oven, etc)
HY	Hybrid coil or junction
DS	Indicator
L	Inductor
MP	Interlock, mechanical
S	Interlock, safety, electrical
RT	Lamp, ballast
HR	Lamp, heating
DS	Lamp, illuminating
DS	Lamp, pilot
RT	Lamp, resistance
DS	Lamp, signal
X	Lampholder
LS	Loudspeaker
MP	Mechanical part
M	Meter
B	Motor
MP	Mounting (not in electrical circuit and not a socket)
N	Nameplate
Z	Network, general (where specific letters do not fit, when considered as a part)
AT	Pad
E	Part, miscellaneous electrical
R	Potentiometer
A	Power supply; source of power
J	Receptacle (connector, fixed)
CR	Rectifier, crystal or metallic
VR	Regulator, voltage (except an electron tube)
MP	Reed, vibrating
K	Relay (electrically operated contactor or switch)
R	Resistor
RT	Resistor, current regulating
R	Resistor, variable
R	Rheostat
CR	Selenium cell
E	Shield, electrical
R	Shunt
X	Socket (see 5.6.1)
L	Solenoid
LS	Speaker; loudspeaker
TB	Strip, terminal
S	Switch (mechanically or thermally operated
*TP	Test point
RT	Thermistor
TC	Thermocouple
M	Thermometer
S	Thermostat
M	Timer
MT	Transducer
T	Transformer
Q	Transistor
V	Tube, electron
Z	Tuned Circuit
CR	Varistor, asymmetrical
RV	Varistor, symmetrical
G	Vibrator, interrupting
DS	Visual signaling device
VR	Voltage regulator (except electron tube)

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS

TO DESIGNATE THE MANUFACTURERS

AD	AUDIO DEVICES	NEW YORK 22, N.Y.
AEO	AEROVOX CORPORATION	NEW BEDFORD, MASS
ASW	AMERICAN SPRING & WIRE	CHICAGO, ILL.
AMP	AMPERITE COMPANY	NEW YORK 12, N.Y.
AH&H	ARROW-HART & HEGEMAN	HARTFORD 6, CONN.
AC	ASTRON CORPORATION	E. NEWARK, N.J.
BC	BARBER COLEMAN CO.	ROCKFORD, ILL.
BIL	BOWMAR INST. LAB	FORT WAYNE, IND.
BU	BULOVA WATCH CO.	FLUSHING, N.Y.
C	CENTRALAB	MILWAUKEE, WIS.
COR	CORNISH WIRE CO.	NEW YORK 7, N.Y.
DP	DAYSTROM PACIFIC	LOS ANGELES, CAL.
DR	DRAKE	CHICAGO, ILL.
EM	ARCO-ELMENCO	NEW YORK 13, N.Y.
ELD	ELDEMA CORP.	EL MONTE, CALIF.
EI	ELECTRO INSTRUMENTS, INC.	SAN DIEGO, CALIF.
EP	ELECTRON PROD.	PASADENA, CALIF.
GE	GENERAL ELECTRIC	CLEVELAND, OHIO
GR	GENERAL RADIO	OAK PARK, ILL.
GA	GOOD-ALL ELECTRIF MFG. CO.	OGALLALA, NEBR.
HO	HOFFMAN SEMI-CONDUCTOR	EVANSTON, ILL.
HIL	HOLT INSTRUMENT LAB.	OCONTO, WIS.
IRC	INTERNATIONAL RESISTANCE CO.	PHILADELPHIA 8, PA.
J	JAMES VIBRAPOWER CO.	CHICAGO, ILL.
LR	LECTRONIC RESEARCH LAB	PHILADELPHIA, PA.
LB	LIBERT BEARING	GREEN BAY, WIS.
LF	LITTLE FUSE	DES PLAINES, ILL.
MAL	MALLORY & CO.	INDIANAPOLIS 6, IND.
OHM	OHMITE	SKOKIE, ILL.
SI	SIMPSON	CHICAGO 44, ILL.
SNC	SNC TRANSFORMER CORP	OSHKOSH, WIS.
SO	SOUTHERN ELECTRONICS CORP	BURBANK, CALIF.
SE	SPECTROL ELECTRONICS	SAN GABRIEL, CALIF.
SP	SPRAGUE	NORTH ADAMS, MASS.
SC	SWITCH CRAFT	CHICAGO 30, ILL.
TO	TOPAZ PRODUCTS, INC.	SAN DIEGO, CALIF.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description		Mfr. & Mfr. Designation
R 101	Resistor, Fixed, Composition 100 K OHMS, 1/2 W, ± 10%		OHM RC-20
R 102	--Same--		-same-
R 103	Resistor, Fixed, Wire Wound 2667 OHM, ± .05%	H I L 286	
R 104	Resistor, Variable, Wire Wound 200 OHM, ± 5%		DP 301-60
R 105	Resistor, Fixed, Wire Wound 3333 OHM, ± .05%	H I L 286	
R 106	Resistor, Fixed, Wire Wound 15 K OHMS, 5 Watt, ± 10%		OHM Brown Devil
R 107	Resistor, Fixed, Composition 1 Meg OHM, 1/2 Watt, ± 10%		OHM RC-20
R 108	--Same--		-same-
R 109	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%		OHM RC-20
R 110	Resistor, Fixed, Composition 22 K OHM, 1/2 Watt, ± 10%		OHM RC-20
R 111	Resistor, Fixed, Composition 1 Meg OHM, 1/2 Watt, ± 10%		OHM RC-20
R 112	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%		OHM RC-20
R 113	Resistor, Fixed, Composition 22 K OHM, 1/2 Watt, ± 10%		OHM RC-20
R 114	Resistor, Fixed, Composition 235 K OHM (2 ea 470 K OHM in Parallel) 1/2 Watt, ± 10%		-same- "
R 115	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%		-same- "
R 116	--Same--		"
R 118	Resistor, Variable, Composition 1 MEG OHM, 2 Watt, ± 20%		OHM CLU 1052
R 119	Resistor, Fixed, Composition 22 K OHM, 1 Watt, ± 10%		OHM RC-32
R 120	Resistor, Fixed, Composition 3.9 K OHM, 1/2 Watt, ± 10%		OHM RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr. Designation
R 121	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 122	--Same--	-same-
R 123	Resistor, Fixed, Composition 68 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 124	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 125	--Same--	-same-
R 126	Resistor, Fixed, Composition 220 OHM, 2 Watt, ± 10%	OHM RC-42
R 201	Resistor, Fixed, Wire Wound 10 OHM, 10 Watt, ± 10%	OHM Brown Devil
R 202	Resistor, Fixed, Wire Wound 125 OHM, 10 Watt, ± 10%	OHM Brown Devil
R 203	Resistor, Fixed, Wire Wound 50 K OHM, 10 Watt, ± 10%	-same- "
R 204	Resistor, Fixed, Wire Wound 30 K OHM, 10 Watt, ± 10%	-same- "
R 205	Resistor, Fixed, Composition 100K OHM, 1/2 Watt, ± 10%	OHM 12C-20
R 206	Resistor, Fixed, Composition 6.8 K OHM, 2 Watts, ± 10%	OHM RC-42
R 207	Resistor, Fixed, Wire Wound 18 K OHMS, 10 Watts, ± 10%	OHM Brown Devil
R 208	Resistor, Fixed, Composition 33 K OHM, 1 Watt, ± 10%	OHM RC-32
R 209	Resistor, Fixed, Composition 1 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 210	--Same--	-same-
R 211	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 212	--Same--	-same-
R 213	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	" "

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr. Designation
R 214	Resistor, Fixed, Composition 10 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 215	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	-same-
R 216	Resistor, Fixed, Composition 10 K OHM, 1/2 Watt, ± 10%	"
R 217	Resistor, Fixed, Composition 47 K OHM, 1/2 Watt ± 10%	"
R 218	Resistor, Fixed, Composition 1 Meg, 1/2 Watt, ± 10%	"
R 219	Resistor, Fixed, Composition 100 K OHM, 1/2 Watt, ± 10%	"
R 220	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	"
R 221	Resistor, Fixed, Composition 180 K OHM, 1/2 Watt, ± 10%	"
R 222	Resistor, Fixed, Deposited Carbon 130 K OHM, 1/2 Watt, ± 1%	IRC DCC RN 20 X
R 223	Resistor, Fixed, Composition 82 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 224	Resistor, Fixed, Deposited Carbon 100 K OHM, 1/2 Watt, ± 1%	IRC DCC RN 20 X
R 225	Resistor, Fixed, Composition 33 K OHM, 1 Watt, ± 10%	OHM RC-32
R 226	Resistor, Fixed, Composition 330 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 227	--Same--	-same-
R 228	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 229	--Same--	-same-
R 230	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	"
R 231	Resistor, Fixed, Composition 10 K OHM, 1/2 Watt, ±10%	"
R 232	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	"

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfrs. & Mfrs. Designation
R 233	Resistor, Fixed, Composition 10 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 234	Resistor, Fixed, Composition 47 K OHM, 1/2 Watt, ± 10%	-same-
R 235	Resistor, Fixed, Composition 1 MEG, 1/2 Watt, ± 10%	"
R 236	Resistor, Fixed, Composition 100 K OHM, 1/2 Watt, ± 10%	"
R 237	Resistor, Fixed, Composition 1 Meg OHM, 1/2 Watt, ± 10%	"
R 238	Resistor, Fixed, Composition 180 K OHM, 1/2 Watt, ± 10%	"
R 239	Resistor, Fixed, Deposited Carbon 75 K OHM, 1/2 Watt, ± 1%	IRC DCC RN 20 X
R 240	Resistor, Fixed, Composition 82 K OHM, 1/2 Watt, ± 10%	OHM DC-20
R 241	Resistor, Fixed, Deposited Carbon 100 K OHM, 1/2 Watt, ± 1%	IRC DCC RN20X
R 242	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 243	--Same--	-same-
R 244	Resistor, Variable, Composition 50 OHM, 2 Watt, ± 10%	OHM CLU 5001
R 245	Resistor, Fixed, Wire Wound 10 OHM, 10 Watt, ± 10%	OHM Brown Devil
R 246	Resistor, Fixed, Wire Wound 100 OHMS, 20 Watts, ± 10%	-same-
R 247	Resistor, Fixed, Wire Wound 1.5 K OHM, 25 Watts, ± 10%	OHM Type 0206
R 248	Resistor, Fixed, Composition 39K OHMS, 2 Watts, ± 10%	OHM RC-20
R 249	Resistor, Fixed, Composition 100K OHMS, 1 Watt, ± 10%	OHM RC-32
R 250	Resistor, Fixed, Composition 390 K OHM, 1 Watt, ± 10%	OHM RC-32

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr. Designation
R 251	-- NOT USED --	
R 260	Resistor, Fixed, Composition 2200 OHMS, 1/2 Watt, ± 10%	OHM RC-20
R 261	--Same--	-same-
R 262	Resistor, Variable, Dual, Composition 25 K OHM/25K OHM, 2 Watt, ± 10%	OHM CCU 2531
R 263	Resistor, Fixed, Composition 33 K. OHM, 1/2 Watt, ± 10%	OHM RC-20
R 264	Resistor, Fixed, Deposited Carbon 470 K OHM, 1/2 Watt, ± 1%	IRC DCC RN20X
R 265	--Same--	-same-
R 266	Resistor, Fixed, Composition 33 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 267	Resistor, Variable, Composition 500 OHMS, 2 Watt, ± 10%	OHM CLU 2511
R 268	Resistor, Fixed, Composition 100 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 269	Resistor, Fixed, Composition 1200 OHMS, 1/2 Watt, ± 10%	-same- "
R 270	--Same--	-same-
R 271	Resistor, Variable, Composition 1000 OHM, 2 Watt, ± 10%	OHM CLU 1021
R 272	Resistor, Fixed, Composition 150 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 273	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	-same-
R 274	Resistor, Fixed, Composition 1 K OHM, 1/2 Watt, ± 10%	"
R 275	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	"
R 276	--Same--	"
R 277	Resistor, Fixed, Composition 1000 OHM, 1/2 Watt, ± 10%	"

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr. Designation
R 278	Resistor, Fixed, Composition 27 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 279	Resistor, Fixed, Composition 1200 OHM, 1/2 Watt, ± 10%	-same-
R 280	Resistor, Variable, Dual, Wire Wound 1 K OHM/10 K OHM, ± 3%	H I L 5-850
R 281	Resistor, Fixed, Composition 270 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 282	Resistor, Fixed, Composition 330 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 283	Resistor, Fixed, Composition 820 OHM, 1/2 Watt, ± 10%	-same-
R 284) R 285)	Resistor, Fixed, Composition 1000 OHM, 1 1/2 Watt, ± 10%	"
R 286	Resistor, Fixed, Composition 220 K OHM, 1/2 Watt, ± 10%	"
R 287	Resistor, Fixed, Composition 30 K OHM, 1/2 Watt, ± 10%	"
R 301	Resistor, Fixed, Wire Wound 10 K OHMS, ± .05%	H I L 520
R 302	--Same--	-same-
R 303	Resistor, Fixed, Composition 6.8 K OHMS, 2 Watt, ± 10%	OHM RC-42
R 304	Resistor, Fixed, Composition 1.8 K OHMS, 1/2 Watt, ± 10%	OHM RC-20
R 305	Resistor, Fixed, Composition 680 OHM, 1/2 Watt, ± 10%	-same-
R 306	Reisitor, Fixed, Deposited Carbon 1 MEG OHM, 1/2 Watt, ± 1%	IRC DCC RN20X
R 307	Resistor, Fixed, Deposited Carbon Value Depends on Unit, 1/2 Watt, ± 1%	IRC DCC RN 20X
R 308	Resistor, Fixed, Deposited Carbon 4.3 MEG OHM, 1/2 Watt, ± 1%	IRC DCC RN 20X
R 309	Resistor, Fixed, Composition 6.8 K OHM, 2 Watt, ± 10%	OHM RC-42
R 310	Resistor, Fixed, Composition 1.8 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 311	Resistor, Fixed, Composition 820 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 312	Resistor, Fixed, Composition 3.9 MEG OHM, 1/2 Watt, ± 10%	-same-
R 313	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	"
R 314	Reisitor, Fixed, Depoaited Carbon 1 MEG OHM, 1/2 Watt, ± 1%	IRC DCC RN 20X

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr. Designation	
R 315	Resistor, Fixed, Composition 1. 2 K OHM, 1/2 Watt, ± 10%		OHM RC-20
R 316	Resistor, Fixed, Deposited Carbon 4.7 MEG OHM, 1/2 Watt, ± 1%		-same-
R 318	Resistor, Fixed, Wire Wound 10 K OHM, 10 Watt, ± 10%		OHM Brown Devil
R 319	Resistor, Fixed, Deposited Carbon 130 K OHM, 1/2 Watt, ± 1%		IRC DCC RN20X
R 320	Resistor, Fixed, Wire Wound 10 K OHM, ± .05%, Flat Bobbin	H I L 520	
R 321	--Same--	-same-	
R 322	Resistor, Fixed, Wire Wound 435 OHM, ± .05 %, Jelly Bean	H I L 286	
R 323	Resistor, Fixed, Deposited Carbon Value Varies with Unit, 1/2 Watt, ± 1%		IRC DCC RN20X
R 324	Resistor, Fixed, Wire Wound 1106 OHM, ± .05 %, Flat Bobbin	H I L 520	
R 325	Resistor, Variable, Wire Wound 10 OHM, ± 5%		DP 301-60
R 326	Resistor, Variable, Composition 100 OHM, 2 Watt, ± 10%		OHM CLU 1011
R 327	Resistor, Fixed, Composition 150 OHM, 1/2 Watt, ± 10%		OHM RC-20
R 328	Same		
R 401	Resistor, Fixed, Wire Wound 100 K OHMS, ± .05 %, Round Bobbin	H I L 185	
R 402	Resistor, Fixed, Wire wound 50K OHMS, ± 0.05% Round Bobbin	-same-	-same-
R 601 to R608	Resistor, Fixed, Wire Wound Mica-Card 100 K OHM, ± .05 %	H I L 602-306	
R 609	Resistor, Fixed, Wire Wound 99 K OHM, ± .05 %, Flat Bobbin	H I L 520	
R 611 to R618	Resistor, Fixed, Wire Wound, Mica Card 10 K OHM ± .05 %	H I L 602-305-2	

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr. Designation
R 657	Resistor, Fixed, Wire Wound 350 OHM, 5 Watt, ± 10%	OHM Brown Devil
R 658	Resistor, Fixed, Wire Wound 400 OHM, 5 Watt, ± 10%	-same-
R 659	Resistor, Fixed, Wire Wound 500 OHM, 5 Watt, ± 10%	-same-
R 660	Resistor, Fixed, Wire Wound 750 OHM, 5 Watt, ± 10%	-same-
R 661	Resistor, Fixed, Wire Wound 1000 OHM, 5 Watt, ± 10%	-same-
R 662	Resistor, Fixed, Wire Wound 1500 OHM, 5 Watt, ± 10%	-same-
R 663	Resistor, Fixed, Wire Wound 2500 OHM, 5 Watts, ± 10%	-same-
R 664	Resistor, Fixed, Wire Wound 5000 OHM, 5 Watt, ± 10%	-same-
R 665	Resistor, Fixed, Wire Wound 15000 OHM, 5 Watt, ± 10%	-same-
R 701	Resistor, Fixed, Composition 2.2 MEG OHM, 1/2 Watt, ± 10%	OHM RC-20
R 702	Resistor, Fixed, Composition 100 K OHM, 1/2 Watt, ± 10%	-same-
R 703	Resistor, Fixed, Composition 10 K OHM, 1/2 Watt, ± 10%	-same-
R 704	Resistor, Fixed, Composition 10 K OHM, 1/2 Watt, ± 10%	-same-
R 705	Resistor, Fixed, Composition 150 OHM, 1/2 Watt, ± 10%	-same-
R 706	Resistor, Fixed, Composition 39 K OHM, 1/2 Watt, ± 10%	-same-
R 707	Resistor, Fixed, Composition 2.2 MEG OHM, 1/2 Watt, ± 10%	-same-
R 708	Resistor, Fixed, Composition 27 K OHM, 1/2 Watt, ± 10%	-same-
R 709	Resistor, Variable, Composition 10 K OHM, 2 Watt, ±10%	OHM CLU 1031

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr's Description
R 619	Resistor, Fixed, Wire Wound 9 K OHM, ± .05 % Flat Bobbin	H I L 520
R 624	Resistor, Fixed, Wire Wound, Mica Card 1000 OHM, ± .05 %	H I L 602-304
R 625 to R-633	--same--	-same-
R 635	Resistor, Fixed, Wire Wound, Jelly Bean 100 OHM, ± .05%	H I L 286
R 636 to 643	--Same--	-same-
R 644	Resistor, Variable, Wire Wound 100 OHMS, ± 1% Special Shaft 1-11/16" long	H I L 130
R 645	Resistor, Fixed, Composition 18 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 646	Resistor, Fixed, Composition 12 K OHM, 1/2 Watt, ± 10%	-same-
R 647	Resistor, Fixed, Composition 27 K OHM, 1/2 Watt, ± 10%	-same-
R 648	Resistor, Fixed, Composition 27 K OHM, 1/2 Watt, ±10%	-same-
R 649	Resistor, Fixed, Composition 100 K OHM, 1/2 Watt, ±10%	-same-
R 650	Resistor, Fixed, Composition 33 K OHM, 1/2 Watt, ±10%	-same-
R 651	Resistor, Fixed, Composition 330 K OHM, 1/2 Watt, ± 10%	-same-
R 652	Resistor, Fixed, Composition 33 K OHM, 1/2 Watt, ± 10%	-same-
R 653	Resistor, Fixed, Composition 56 K OHM, 1/2 Watt, ± 10%	-same-
R 654	Resistor, Fixed, Composition 27 K OHM, 1/2 Watt, ±10%	-same-
R 655	Resistor, Fixed, Wire Wound 2250 OHM, 25 Watt, ±10%	OHM 03773
R 656	--same--	-same-

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr's Designation
R 710	Resistor, Fixed, Composition 27 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 711	Resistor, Fixed, Composition 270 K OHM, 1/2 Watt, ± 10%	-same-
R 712	Resistor, Fixed, Composition 47K OHM, 1 Watt, ± 10%	-same-
R 713	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	-same-
R 714	Resistor, Fixed, Composition 3.9 K OHM, 1/2 Watt, ± 10%	-same-
R 715	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	-same-
R 716	Resistor, Fixed, Composition 47 K OHM, 1 Watt, ± 10%	OHM RC-32
R 717	Resistor, Fixed, Composition 22 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 718	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	-same-
R 719	Resistor, Fixed, Composition 100 K OHM, 2 Watt, ± 10%	OHM RC-42
R 720	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	OHM RC-20
R 721	Resistor, Fixed, Composition 220 K OHM, 1/2 Watt, ± 10%	-same-
R 722	--Same--	-same-
R 723	Resistor, Fixed, Composition 47 OHM, 2 Watt, ± 10%	OHM RC-42
R 724	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 725	Resistor, Fixed, Composition 560 OHM, 2 Watt, ± 10%	OHM RC-42
R 726	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 727	Resistor, Fixed, Composition 47 OHM, 2 Watt, ± 10%	OHM RC-42
R 728	Resistor, Fixed, Composition 47 OHM, 2 Watt, ± 10%	-same-

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr's Description
R 729	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 730	Resistor, Fixed, Composition 560 OHM, 2 Watt, ± 10%	OHM RC-42
R 731	Resistor, Fixed, Composition 100 OHM, 1/2 Watt, ± 10%	OHM RC-20
R 732	Resistor, Fixed, Composition 47 OHM, 2 Watt, ± 10%	OHM RC-42
R 733	Resistor, Fixed, Composition 33 K OHM, 1/2 Watt, ± 10%	OHM RC-20
R 734	Resistor, Fixed, Composition 2.7 K OHM, 1/2 Watt, ± 10%	-same-
R 735	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%	-same-
R 736	Resistor, Fixed, Composition 1 MEG OHM, 1/2 Watt, ± 10%	-same-
R 737	Resistor, Fixed, Composition 470 K OHM, 1/2 Watt, ± 10%	-same-
C 101	Capacitor, Fixed, Mylar Paper, .05 MFD, 400 V. DCW IN Z 102	SP 4TMS 5
C 102	-- same as above --	- same -
C 103	Capacitor, Fixed, Metalyte 1.MFD, 200 V DCW IN Z 102	AC ML-2-1M
C 104	Capacitor, Fixed, Bath tub 2 MFD, 600 V DCW	AEO JP-630M
C 105	Capacitor, Fixed, Metalized Paper .1 MFD, 200 V DCW	AEO P 123Z
C 106	Capacitor, Fixed, Mylar Paper .05 MFD, 400 V DCW	SP 4TMS5
C 107	Capacitor, Fixed, Triple Section 20-20-40 MFD, 250 V DCW	SP TVL-3549
C 108	Capacitor, Fixed, Mylar Paper .05 MFD, 400 V DCW	SP 4TM-S5
C 109	Capacitor, Fixed, Silvered Mica 5600 MMFD, 500 V DCW ±2% IN Z 103	EM CM-40
C 110	Capacitor, Fixed, Silvered Mica 5600 MFD, 500 V DCW, ± 2% IN Z 103	EM CM-40

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfrs. & Mfrs. Designation
C 111	Capacitor, Fixed, Silvered Mica 11200 MMFD (2, - 5600 MMF in parallel) 500 V DCW, ± 2%. in Z 103	EM CM-40
C 112	Capacitor, Fixed, Disc .01 MFD, 600 V DCW	C DD6-103
C 113	Capacitor, Fixed, Mylar Paper .05 MFD, 400 V DCW	SP 4TM-S5
C 114	-- same as above --	-same-
C 201	Capacitor, Fixed, Double Section 40-40 MFD, 450 V DCW	MAL FP-238
C 202	Capacitor, Fixed, Mylar Paper .05 MFD, 400 V DCW	SP 4TM-S5
C 203	Capacitor, Fixed, Double Section 40-40 MFD, 450 V DCW	MAL FP-238
C 204	Capacitor, Fixed, Disc .01 MFD, 600 V DCW	C DD6-103
C 205	Capacitor, Fixed, Single Electrolytic 50 MFD, 150 V DCW	MAL FP 115
C 206	Capacitor, Fixed, Electrolytic, Metal Cad, 2000 MFD, 15 V DCW	MAL WP-041
C 207	Capacitor, Fixed, Electrolytic, Triple Section, 80-40-20 MFD, 450 V DCW	MAL FP378
C 208	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 V DCW, ± 10%	E.M. DM-15
C 209	-- same --	-same-
C 210	Capacitor, Fixed, Dur-Mica 15 MMFD, 500 V DCW ± 10%	E M DM-15
C 211	Capacitor, Fixed, Dur-mica 1200 MMFD, 500 V DCW ± 10%	E M DM-15
C 212	NOT USED	
C 213	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 V DCW, ± 10%	E M DM-15
C 214	Capacitor, Fixed, Dur-Mica 820 MMFD, 500 V DCW, ± 10%	E.M. DM-15
C 215	Capacitor, Fixed, Dur-Mica 15 MMFD, 500 V DCW, ± 10%	-same- "
C 216	Capacitor, Fixed, Dur-Mica 1200 MMFD, 500 V DC, ± 10%	"
C 217	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 V DCW, ± 10%	"

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfrs. & Mfrs. Designation
C 218	Capacitor, Fixed, Dur-Mica 820 MMFD, 500 V DCW, ± 10%	
C 219	Capacitor, Fixed, Mylar Dielectric .2 MFD, 400 V DCW	G.A. 600 UE
C 220	Capacitor, Fixed, Electrolytic, Small 15 MFD, 25 V DCW	SP TE 1205
C 260	-- same --	-same-
C 261	Capacitor, Fixed, Dur-Mica 5600 MMFD, 500 V DCW, ± 10%	EM DM-15
C 262	-- same --	-same-
C 263	Capacitor, Fixed, Metalized Paper 2.5 MFD, 400 V DCW	EP M4-36
C 265	Capacitor, Fixed, Metalized Paper .22 MFD, 400 VDCW	AEO P 123Z
C 266	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	C DD6-103
C 267	Capacitor, Fixed, Dur-Mica 75 MMFD, 500 VDCW, ± 10%	EM DM-15
C 268	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	SP 4TM-S5
C 269	Capacitor, Fixed, Metalized Paper .22 MFD, 400 VDCW	AEO P-123Z
C 270	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	C 006-103
C 302	Capacitor, Fixed, Dur-Mica 1500 MMFD, 300 VDCW, ± 10%	EM DM-15
C 303	Capacitor, Fixed, Dur-Mica 910 MMFD, 300 VDCW, ± 10%	EM DM-15
C 304	Capacitor, Fixed, Metalized Paper .22 MFD, 200 VDCW	AEO P 123Z
C 305	Capacitor, Fixed, Mylar Paper .01 MFD, 400 VDCW	SP 4TM-S1
C 306	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	C DD6-103
C 307	Capacitor, Trimmer, Tubular 1 - 7.5 MMFD, 600 VDCW	C 829-7
C 308	Not used	
C 309	Capacitor, Fixed, Dur-Mica 1200 MMFD, 300 VDCW	EM DM-15
C 310	Capacitor, Fixed, Dur-Mica 910 MMFD, 300 VDCW	EM DM-15

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfrs. Designation
C 311	Condenser, Fixed, Metalized Paper Varies according to Unit	EP
C 312	Capacitor, Fixed, Mylar Paper .01 MFD, 400 VDCW	SP 4TM-S1
C 313 to 316	NOT USED	
C 317	Capacitor, Fixed, Dur-Mica 430 MMFD, 500 VDCW	EM DM-15
C 318	Capacitor, fixed, Mylar 5 MFD, 200 VDCW, ± 10%	SO MY-5-10-200E
C 319	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 VDCW	E M DM-15
C 401	Capacitor, Fixed, Mylar .22 MFD, 100 VDCW, ± 1%	GA 663 UW
C 402	Capacitor, Fixed, Mylar .275 MFD, 100 VDCW, ± 1%	GA 620UPB
C 403	Capacitor, fixed, Mylar .043 MFD, 100 VDCW, ± 1%	GA 663 UW
C 404	Capacitor, Fixed, Mylar .35 MFD, 100 VDCW, ± 1%	GA 620 UPB
C 405	Capacitors, Fixed, Mylar .35 MFD, 100 VDCW, ± 1%	GA 620 UPB
C 406	Capacitor, Fixed, Mylar .033 MFD, 200 VDCW, ± 1%	GA 663 UW
C 407	Capacitor, Fixed,Mylar .275 MFD, 100 VDCW, ± 1%	GA 620 UPB
C 408	Capacitor, Fixed, Mylar .22 MFD, 100 VDCW, ± 1%	GA 663 UW
C 601	Capacitor, Fixed, Dur-Mica 360 MMFD, 300 VDCW	EM DM-15
C 602	Capacitor, Fixed, Dur-Mica 620 MMFD, 300 VDCW	E M DM-15
C 701	Capacitor, Fixed, Metalized Paper .1 MFD, 200 VDCW	AEO F 123Z
C 702	Capacitor, Fixed, Electrolytic Small 110 MFD, 3 VDCW	SP TE 1060
C 703	Capacitor, Fixed, Metalized Paper .22 MFD, 400 VDCW	AEO P 123Z

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfrs. & Mfrs. Designation
C 704	Capacitor, Fixed, Metalized Paper .22 MFD, 400 VDCW	-same-
C 705	--Same--	"
C 706	Capacitor, Fixed, Paper .02 MFD, 400 VDCW	MAL GEM-612
C 707	--Same--	-same-
C 708	Capacitor, Fixed, Dur-Mica 22 MMFD, 500 VDCW Adjusted for minumum distortion	EM DM-15
C 709	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	C DD6-103
C 710	Capacitor, Fixed, Metalized Paper .1 MFD, 400 VDCW	AEO P 123ZG
C 711	Capacitor, Fixed, Electrolytic 300 MFD, 3 VDCW	SP TE-1066
CR 101	Diode, Zener, Silicon Minimum Breakdown V. 5.9	HO IN 429
CR 220	Diode, Crystal General Purpose P.I.V. 84 Volts	SYL IN 48
CR 221	--Same--	-same-
CR 301	Diode, Quick Recovery, Silicon P.I.V. - 125 V. 4 MA	HU IN 628
CR 302	--Same--	-same-
CR 303	--Same--	"
K 201	Relay, Medium Power 8 Amp. 115 V. DPDT	GU IR-1200-6115
L 301	Choke, RF 750 UH, 250 MA	MIL 34300-750
L 302	13 Turns # 28Wire Wound on R 327	
L 303	13 Turns # 28 Wire Wound on R 328	
L 401	Choke, Audio 720 OHM DC	H I L 71018
CR 230	Rectifier, Silicon, 425 MA IN 1109, Max. P.I.V. 1200 Volts	ST 120 SM
CR 231 234	--Same--	-same-
CR 235 238	Rectifier, Silicon, .75 MA Max. P.I.V. 200 Volts	ST F-2

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr's Description
L 402	Choke, Audio 5500 OHM DC	H I L P 3751
L 403		
L 404	Choke, Audio 2340 OHM, DC	H I L 7813
L 405	Choke, Audio 720 OHM DC	H I L 71018
V 101	Tube, Electron	RCA 12AX7
V 102	-same-	-Same-
V 103	Tube, Electron	RCA 6AQ5
V 104	--Same--	-same-
V 201	Tube, Electron	RAY CK 5783
V 202	Tube, Electron	RCA 0B2
V 203	--Same--	RCA 12AV7
V 204	--Same--	RCA 6BR8
V 205	--Same--	RCA 12AX7
V 206	--Same--	RCA 12AV7
V 207	--Same--	RCA 6BR8
V 208	--Same--	RCA 12 AX7
V 209	--Same--	RCA 12 AV7
V 210	--Same--	RCA 6AU6
V 211	--Same--	RCA 5687
V 301	--Same--	RCA 6136

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr's Designation
V 302	--Same--	RCA 6AU6
V 303	--Same--	RCA 6 AU6
V 304	--Same--	RCA 5687
V 701	--Same--	RCA 6AB4
V 702	--Same--	RCA OB2
V 703	Tube, Electron	RCA 12AX7
V 704	--Same--	RCA 12AU7
V 705	"	RCA 12AU7
V 706	"	RCA 12AX7
V 707	"	RCA 5881
V 708	"	-same-
V 709	"	"
V 710	"	"
Z 101	Oven Temp. 55°c., 117 VAC	BU FC 100
T 101	Transformer, OUTPUT	H I L P3750
T 201	Transformer, Power	H I L 71101-2
T 202	Transformer, Filament	H I L P 3713
T 203	Transformer, Plate	H I L P 3932
T 601	Transformer, Hi-Voltage	H I L 80915
T 701	Transformer, OUTPUT	H I L 80916

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description		Mfr. & Mfr. Designation
BT 101	Battery, Mercury 1.3 VDC .450" x .125"		MAL RM-400R
B 201	Motor, Servo, 2 Phase	H I L FPE-2512	
B 202	Motor, AC		BC DYAB-5713
B 203	Fan, Blade		BC YAR-330A
P 201	Line Cord, 3 Conductor		COR 3532
S 201	Relay, Time Delay 115 Volt		AMP
S 202	Not used		
S 203	Switch, Bat Handle, Toggle SPST, 3 Amp, 250 V.		AH&H 20994-LH
S 204	Switch, Bat Handle, Toggle DPDT, 3 Amp, 250 V.		AH&H 81027-CE
S 205	Switch, Lever, Locking 120 Volts, 3 Amp		SC 3006L
S 600	100 Volt Decade Switch Assembly		HIL 600
S 601	10 Volt " " "		HIL 601
S 602	1 Volt " " "		HIL 602
S 603	0.1 Volt " " "		HIL 603
S 604	Load Watts Switch		HIL 604
M 201	Meter 0-200 DC Micro-Amp	HIL 1227 Simpson	HIL MM-2 Marion
I 201	Lamp, Incandescent 230 V., 10 Watt		GE Type S 6
I 202	Lamp, Neon, Indicating 65-130 VAC, 90-130 VDC		DR Type 105
I 203	--same--		-same-
I 204	--same--		-same-
I 205	Lamp, Neon, Miniature, Indicating Clear Lens with 100 K ohm Res.		ELD Type IEG3
I 206	--same--		-same-

TABLE OF REPLACABLE PARTS

Circuit Ref.	Description	Mfr. & Mfr's Description
F 201	Fuse, SLO-BLO 3 AG, 2 Amp	L.F. 313002
F 202	Fuse, SLO-BLO 3 AG, 4 Amp	L.F. 313004
G 101	Chopper	J C2342

INPUT LEVEL METER

EXTERNAL VARIABLE FREQUENCY OSCILLATOR

INTERNAL 60 CYCLE OSCILLATOR

60CPS

SERVO DRIVEN POTENTIOMETER

27K

1M

INPUT CIRCUITRY

SERVO AMPLIFIER

SERVO MOTOR

1026-C

VOLTAGE CONTROL

1048-C

AC to DC CONVERTER

+50 VOLT REGULATOR

DC REFERENCE

DC REFERENCE

CHOPPER

FILTER

10K

HIGH VOLTAGE CALIBRATION

T701

HIGH VOLTAGE OUTPUT TRANSFORMER

LOW VOLTAGE OUTPUT TRANSFORMER

10 VOLT

OUTPUT

COMMON

30K EACH

3K

300Ω EACH

30Ω EACH

30Ω

100 VOLT STEPS

10 VOLT STEPS

1 VOLT STEPS

0.1 VOLT STEPS

0 TO 0.1 VOLT POT

HILT INSTRUMENT LABORATORIES, OCONTO, WISCONSIN			
MAT'L.	TITLE BLOCK DIAGRAM		
FINS	DATE 6-5-59	MODEL 6V5-32	
TOLERANCE UNLESS NOTED FRACT. DEC. SCALE	APPROVED	DRAWING NO 1041-C	CHNG.
	DRFT		

NO.	X	DATE	DESCRIPTION	APP'D
A	—	2-6-6	AID R 287	RD
B	1029	3-27-68	FIL ENA [illegible]	RL

TERMINATION G
VOLTAGE CONTROL DRWG # 1006-C

25C FROM SERVO POT SHLD
26F INPUT TO AMP SHLD
24E IV OUTPUT GRN

TERMINATION E
A.C.-D.C. CONVERTER DRWG # 1045

24G 1V INPUT SIG GRN
[illegible] A -27 VDC BRN
[illegible] A COMMON BLK
3B -250 VDC REG GRY/WHT
20B +150 VDC REG YEL/WHT
21A, 23A 6.3 VAC FIL BLU/WHT
[illegible] -7 VDC FIL BRN/WHT LT BLU
67A, 70A 6.3 VAC FIL BRN/W BRN
11D SIG OUT GRN/WHT
12D COMMON

TERMINATION D
SERVO AMPLIFIER DRWG # 1042-[illegible]

[illegible]E [illegible]
2E COMMON
[illegible]L [illegible]
1A [illegible]
3A [illegible]
4A [illegible]
4E [illegible]
[illegible]A [illegible]
7A COMMON
8A LINE NEUTRAL
9A [illegible] YEL
[illegible] [illegible]
[illegible] [illegible]
[illegible] OVEN LIGHT
[illegible] [illegible]
[illegible] [illegible]
[illegible] OVEN LIGHT

TERMINATION B
POWER SUPPLY REGULATORS DRWG # 1016-C

RED/WHT, ORA/WHT, ORA/WHT +250 VDC REG (29C, 39F, 53B)
PURP/WHT +400 VDC 54B
BRN, BRN/WHT 6.3 VAC FIL (55B, 56B)
BRN/WHT, RED 6.3 VAC FIL (65A, 66A)
PINK, PINK +105 VDC (57A, 58B)
BLK, BLK COMMON (59A, 60B)
J 203

ORA/WHT +250 VDC REG 53B
YEL, YEL/WHT, YEL/WHT, GRY/BLK +150 VDC REG (30F, 20E, 40E, 32C)
ORN/WHT +105 VAC 33F
PURP/WHT, PURP/WHT +400 VDC (54B, 61A)
BRN/WHT, GRN, BRN, BRN 6.3 VAC FIL (67A, 68A, 65B, 62A)
BRN/WHT, BRN/WHT 6.3 VAC FIL (56B, 63A)
PINK +105 VDC 58B
BLK COMMON 60B
J 205

TERMINATION A
POWER SUPPLY DRAWING # 1019-[illegible]

BRN -27 VDC 11E
PURP/[illegible] +25 VDC [illegible] 1C
PINK +105 VDC 57B
PURP/WHT +400 VDC 61B
GRY/WHT -105 VDC 34F
BLU/WHT -250 VDC 37F
DK BLU +410 VDC 46F
BLU/WHT 115 VAC CHOPPER 2D
BLK/WHT 115 VAC OVEN 3D
WHT LINE NEUTRAL 8D
BLK COMMON 35F
BLK COMMON 59B
BLK COMMON 31C
BLK COMMON 7D
BLK COMMON 18E

21E, 22E 6.3 VAC
23E -5 VDC
5D +5 VDC
9D, 10D 6.3 VAC
28C, 27C 6.3 VAC
62B, 63B 6.3 VAC
35F, 36F 6.3 VAC
40F, 41F 6.3 VAC
42F, 43F 6.3 VAC

BRN/WHT, RED 6.3 VAC FIL @ 250V 65B 66B 71C 72C 6.3 VAC (BRN/WHT, BRN)
BRN/WHT, GRN, BRN/WHT, BRN 6.3 VAC FIL @ 150V 61B 68B 69E 70E

TERMINATION C
INPUT CIRCUITRY DRWG # 1058-C

GRY/BLK +150 VDC REG 32D
SHLD SERVO POT 25G
SHLD DAMPING VOLTAGE 16D
BLK COMMON 31A
YEL +150 VDC REG 30B
RED/WHT +250 VDC REG 29B
BRN/WHT, YEL 6.3 VAC FIL (28A, 27A)
RED/WHT SIGNAL TO LEVEL CATHODE FOLLOWER 49F
GRN/BLK METER SIGNAL 50F
BRN/WHT, BRN 6.3 VAC FIL (71A, 72A)

TERMINATION F
POWER AMPLIFIER DRWG # 1024-C

ORA/BLK +105 VDC 33B
GRY/WHT -105 VDC 34A
YEL, BRN/WHT 6.3 VAC FIL V701, 3, 4, 5, 6 (35A, 36A)
BLU/WHT -200 VDC 37A
BLK COMMON 38A
ORA/WHT +250 VDC REG 39B
BRN/WHT, PINK 6.3 VAC FIL V709, V710 (40A, 41A)
BRN/WHT, BLU 6.3 VAC FIL V707, V708 (42A, 43A)
[illegible]SHLD FEEDBACK 44F
[illegible]SHLD INPUT 26G
[illegible]SHLD INPUT SHORTING 45F
DK BLU +410 VDC 46A
[illegible]SHLD PIN 8 OUTPUT TRANS 44F
[illegible]SHLD STAND BY-OP SW 45F
BRN PLATE V709 V710 47F
RED/BLK PLATE V707 V708 48F
RED/WHT SIG TO LEVEL CATHODE FOLLOWER 49
GRY/BLK SIG TO METER 50C
BLK/WHT CATHODES 5B-1 51F
BLK/WHT PIN 3 OUTPUT TRANS 51F
BRN PIN 6 OUTPUT TRANS 47F
RED/BLK PIN 4 OUTPUT TRANS 48F

LEGEND !
WIRE NUMBERS ARE THE SAME ON EITHER END OF THE CONDUCTOR. THE TERMINATION LETTER INDICATES ON WHAT SUB ASSEMBLY A PARTICULAR WIRE WILL TERMINATE.

EXAMPLE :

24 G — TERMINATES ON VOLTAGE CONTROL DRWG # 1006-C

HI LAB INSTRUMENT LABORATORIES
OCONTO WISCONSIN

TITLE [illegible]
DATE 10-[illegible]-68
APPROVED
DRAWN
MODEL [illegible]
DRAWING NO 1069-C
CHNG B

MAT'L
FIN
TOLERANCE UNLESS NOTED FRACT. DEC. ANG.
SCALE

MK	XC	DATE	DESCRIPTION	INT
A	[illegible]	12-59	NEW 1058-C	RD
B		1-13-60	ADDED C 260	RD
C	1137	1/27/60	CHNG TOL. ON R279	RD

F O +250 REG. SEE DRWG # 1018C - 1058C

R 272 1200

V 211 A 5687

C 265 .22 MFD 400V

SEE DRWG # 1018C & 1058C

R 262-A 25K FREQUENCY

R 263 33K

C 261 5600 MMF

C 270 .01 MFD

C 267 33 MMF

R 264 470K 1%

R 268 100K

GAUG V 210

-150 V REG.

TERM # 9

TERM # 10

TO T-201

R 288 270K

C 266 5600 MMF

R 265 470K 1%

R 269 1200

R 261 500

RT 201 250V 10W

R 270 150Ω

R 271 1K

C 263 2.5 MFD 400V

V 211 B 5687

C 264 1.0 MFD 400V

R 274 27K

C 270 .01 MFD

R 284 330Ω

R 213 1K

CHASSIS

COMMON

INPUT

FRONT PANEL TERM. # 1

S 205

60 CW

EXT

60 CW

EXT

R 283 820

R 262-B 1K

COMMON H

CONNECTS TO CONNECTION BOX DRWG # 1017C

+350 V REG. SEE DRWG # [illegible]

F

V-701 6N84

(APPROX. LOCATED ON POWER SUPPLY PLATE SHOWING 250V)

TO VOLTAGE CONTROL (INPUT VOLTAGE) DRWG # 1006C

I

TO SERVO AMP. (DAMPING VOLTAGE) DRWG # 1026C

+150 V REG.

SEE DRWG. 1018C PIN Z J203

R 279 1200 1%

R 280-B 10Ω

R 277 100Ω 1W

C 229 15 MFD 25V

C 260 INSTALL

25V

R 289

R 281 2.2K

0-100 MA M202

CR 280 1N48

CR 281 1N48

R 280 2.2K

R 201 [illegible]

-SEE SERVO-AMP

SEE DRWG # 1026C

SEE SERVO AMP

HILT INSTRUMENT LABORATORIES

OCONTO WISCONSIN

MAT'L		TITLE INPUT CIRCUITRY	
FIN.		DATE 10-1-59	MODEL AVS-321
TOLERANCE UNLESS NOTED FRACT. DEC.	SCALE	APPROVED	DRAWING NO 1058-C CHNG C
		DRFT R.D.	

CHG	XC	DATE	DESCRIPTION	BY
B	1028	2-12-60	CHG TO 300 % VOLT ATTENUATOR	RD
C	1031	4-5-60	ELIMIATE HIGH FREQ. COMPENSATION	

FROM SERVO-POT DRWG. #1042 C

C 602 620

R 666 30K 1%

C 601 360

Z DRWG #1024

C 603 620

R 667 47K 1%

R 668 22K

100 VOLT STEPS

S 600-H

10 VOLT STEPS

S 601-G

S 600-G

S 601-F

S 600-F

S 602-D

R677 18K R769 18K R681

18K R768 18K R680 18K

S 603-C

100K R675 39K R673 10K R671 4.7K R669

R649 39K R674 10K R672 10K R670 4.7K

1 VOLT STEPS

S 602-C

300 R632 300 R630 300 R628 300 R626

R633 300 R631 300 R629 300 R627 300

R623 300

S 603-B

R643 30 R641 30 R639 30 R637 30 R635

R644 30

0-.1 VOLTS VARIABLE

0.1 VOLT STEPS

B DRWG #1048

30K R602 30K R604 30K R606 30K R608 29.7K

R601 30K R603 30K R605 30K R607 30K R609

S 600-D

S 602-B

R624 300

3K R617 3K R615 3K R613 3K R611

R618 3K R616 3K R614 3K R612 3K

S 601-B

R619 2.7K

S 602-A

S 603-A

S 600-C

S 600-B

BUSS

BRN/W

S 600-A

RED GREY PURP BLUE GREEN YELLOW ORANGE GREY/WHT WHT

TAN/W TAN

T601

OUTPUT

BUSS

S 601-A

TAN DK BLU PINK PURP/W BLU/W GRN/W YEL/W ORN/W RED/W BRN

ALL #18 WIRE

GREY PURP BLUE GREEN YELLOW ORANGE RED BRN WHITE BLACK

T 701
FOR PRIMARY WINDINGS
SEE DRWG# 1024

PURP/W

WHT #18

RED/W

GRN/W

GRN

CHASSIS

10 AMP

COMMON

ALL FIVE WATT

R657 400 R659 750 R661 1.5K R663 5K R665

350 R658 500 R660 1K R662 2.5K R664 13K

R656 2250 25W

R655 2250 25W

S 604 LOAD WATTS

HILT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

TITLE VOLTAGE CONTROL

MAT'L

FIN.

TOLERANCE UNLESS NOTED FRACT. DEC. SCALE

DATE 2-24-60

APPROVED

DRFT RD

MODEL AV5-321

DRAWING NO. 1006

CHNG C

NOTE:
C311 + R323 ARE FACTORY ADJUSTED, SEE MANUAL.

C409 12MMF
R403 470K
C311
R324
R323 500Ω
1 VOLT RMS SIGNAL FREQ. SMOOTH SINE WAVE NO HUM OR NOISE
REGULATED +150
R308 6.8M 2W
R309 6.8M 2W
R310 1.8M
R311 880Ω
C302 560MMF
C303 910MMF
C309 1200 MMF
C310 910 MMF
R304 1.5M
R305 6810Ω
R307 5.6MEG
C301 1-7.5MMF
C400
R312 3.2M
C312 .1
R313 1 M
REGULATED +250
V304 5687
V301 6AU6
V302 6AU6
CR303 IN668
NOTE: 28 VOLTS PEAK ~ 10 VOLTS DC
TP 304
R321 2K
R320 1K
R322 435Ω WW .05%
R329 10
R325 10Ω
R326 66K
R306 1M 1%
R314 1M 1%
R315 1M
R316 499 MMF
R317 10K 10W
R318 10K
R319 1M
R401 100K WW .05%
TP 307
TP 306
TOPAZ 7818 L401 720Ω DC
SNC P3751 L402 5500Ω DC
TOPAZ 7812 L403 231Ω DC
TOPAZ 7813 L404 2430Ω DC
TOPAZ 7818 L405 720Ω DC
C401 .22 MFD ±1%
C403 .243 MFD ±1%
C406 .033 MFD ±1%
C408 .22 MFD ±1%
C402 .275 MFD ±1%
C404 .35 MFD ±1%
C405 .35 MFD ±1%
C407 .275 MF ±1%
L301 RFC 750 MH
C304 .01 MFD
R402 10K WW .05%
COMMON
+250 V REG
-27 V
PIN 4 V301 -5 VDC
TO SERVO AMP DRWG # 1026C
B A

NOTE:
C301 + R307 ARE FACTORY ADJUSTED SEE MANUAL

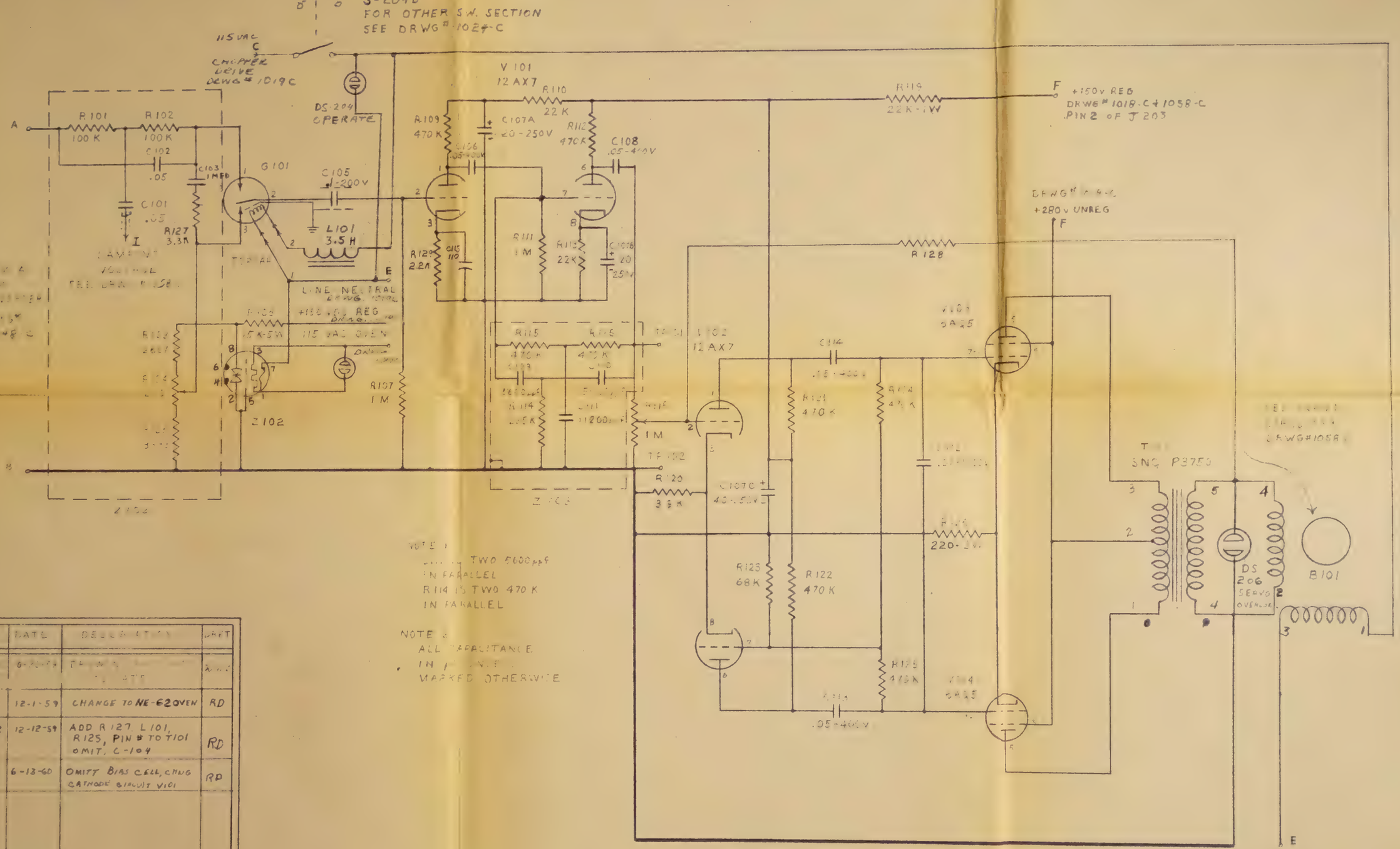
NOTE:
10 RANGE RESISTORS DESIGNATED AT TERMINAL ON BASE OF VOLTAGE CONTROL POTENTIOMETER

NOTE:
SIGNAL FREQ. SINE WAVE, 29 VOLTS PEAK
NOTE JUMP AT ZERO CROSSING APPROX. 1 VOLT

CHNG	XC	DATE	DESCRIPTION	CHK
A	UP THROUGH 1017	10-31-59	SCEMATICS BROUGHT UP TO DATE	RD
B	—	5-3-60	ADD COMPENSATION	RD
C	1034	6-12-61	ADJ R 329	RD

HILL INSTRUMENT LABORATORIES
OCONTO, WISCONSIN

TITLE AC-DC CONVERTER
MODEL AVS-321
DRAWING NO 1048-C
CHNG C
DATE 10-31-59
APPROVED
DRFT RD
MAT'L.
FIN.
TOLERANCE UNLESS NOTED FRACT. DEC.
SCALE



NOTE 1
R115 IS TWO 560K IN PARALLEL
R114 IS TWO 470 K IN PARALLEL

NOTE 2
ALL CAPACITANCE IN MFD UNLESS MARKED OTHERWISE

CHNG	NO	DATE	DESCRIPTION	DRFT
A	[illegible]	8-20-59	[illegible]	[illegible]
B	1021	12-1-59	CHANGE TO NE-62 OVEN	RD
C	1022	12-12-59	ADD R 127 L 101, R 125, PIN # TO T101 OMIT, C-104	RD
D	1035	6-13-60	OMITT BIAS CELL, CHNG CATHODE CIRCUIT V101	RD

HILL INSTRUMENT LABORATORIES
OCONTO, WISCONSIN

MAT'L.	TITLE SERVO AMPLIFIER	
FIN.	DATE 7-27-59	MODEL AVS 321
TOLERANCE UNLESS NOTED FRACT. DEC.	APPROVED	DRAWING NO. 1026
SCALE	DRFT W. M. L.	CHNG. D

LTR	ECO	DATE	DESCRIPTION	APPD
A	[illegible] 1011	10-31-59	SCHEMATICS BROUGHT UP TO DATE	RD
B	1027	1-27-60	R116, R117 & C 708 [illegible]	WJ

V 703-B
½ 12AX7

V 704-A
12AU7

V705-A
12AU7

V 706-A
12AX7

V 709
5881

V 710
5881

BUSS WIRE

R 725
560Ω
2W

T 701

BROWN

R 712
47K
1W

C 706
.02MF

R 724
100Ω

R 726
100Ω

R 739
100Ω

SECONDARY CONNECTIONS SHOWN DRWG # 1006

INSTRUMENT INPUT ATTN. / VOLUME CONTROL

Z

C 701
0.1MF
200V

R 702
.05M

C 711
30E MFD
3V

R 734
10K

R 735
15K
1%

R 701
2.2M

R 707
2.2M

R 708
27K

R 713
1M

C 704
.22MF
400V

R 736
39K

R 709
10K

R 714
3.9K

R 718
1M

R 721
220K

R 717
22K

R 719
100K
2W

R 710
22K

R 715
1M

R 720
1M

R 722
220K

C 708
47 MMF

R 733
27K
1%

C 703
.22 MF
400V

C 705
.22 MF
400V

C 707
.02 MF
600V

V706-B

R 716
47K
1W

V 704-B

V 705-B

R 729
100Ω

R 731
100Ω

R 738
100Ω

V 707
5881

V 708
5881

R 730
560Ω
2W

BUSS WIRE

DRWG # 1019
+410
N

ORN BLUE

COMMON
H

BLACK

DRWG # 1018 PIN 4 J 203
+105
P

ORN/BLK

DRWG 10.8. REG +250

ORN/W

-200
DRWG 1019
Q

BLU/W

-105
L
DRWG # 1018

GREY/W

V 702
0B2

V 703
½ 12AX7

R 740
910K

C 709
.001 MF
1KV DISC.

R 737
470K

C 710
.1 MFD
400V
P123ZG

R 735
470K

HILT INSTRUMENT LABORATORIES
OCONTO, WISCONSIN

MAT'L		TITLE POWER AMPLIFIER	
FIN		DATE 10-31-59	MODEL AVS-321
TOLERANCE UNLESS NOTED FRACT DEC	SCALE	APPROVED CPD	DRAWING NO. 1024-C
		DRFT RL	CHNG B

LTR	X-C	DATE	DESCRIPTION	APP'D
A	[illegible] 1019	7-6-59	DRAWING NO. ON PC BOARD.	RL
B	1069	3-25-60	FILAMENT CHG.	RL
C	–	3-29-60	ADD R 281	RO

V209 12AV7
R274 1M
R275 100Ω
R271 1M
R270 100Ω
R209 1M
R211 100Ω
V203 12AV7
R210 1M
R212 100Ω
R208 33M 1W
V212-B 12AV7
R217 47K
R281 [illegible]
R214 1M
V212-A 12AV7
R216 10M
R222 [illegible]
C215 15 MMF
R215 1M
C217 [illegible]
R221 [illegible]
C216 .2 MF
C218 [illegible]
R223 1M
R224 [illegible]
PL-202
J202 SHOWN ON DRAWING # 1069-C
400 V
6.3 VAC V209 V212
6.3 VAC V209 V203
105 V
COM.

R234 1K
V206 12AV7
R228 110
R227 15[illegible]
150 V
250 V
R235 1K
R225 33K 1W
R226 330K
C208 100 MMF
R234 47K
R230 1M
R288 68K 1W
R238 180K
R233 1M
C214 820 MMF
R239 75K 1%
V213-B 12AV7
V213-A 12AV1
R231 1K
R232 10M
C212 15 MMF
R229 1M
C213 100 MMF
R236 100K
V201 CK5783
C211 1200 MMF
R237 1M
R240 82K
R241 [illegible] 1%
V208 12AV1
R242 470K
COM.
P-203
R287 39K
6.3 VAC V208 V213
6.3 VAC V206
J203 SHOWN ON DRAWING # 1069-C
COM.

HOLT INSTRUMENT LABORATORIES
OCONTO, WISCONSIN

MAT'L		TITLE	POWER SUPPLY REGULATED
FIN		DATE 9-30-57	MODEL AVS-321
TOLERANCE UNLESS NOTED FRACT. DEC. SCALE		APPROVED D.I.S	DRAWING NO. 1018C
		DRFT R.L.	CHNG C

CHNG	XC	DATE	DESCRIPTION	DRFT
A	UP THROUGH 1017	9-26-59	Schematics BROUGHT UP TO DATE	R D
B		1-13-59	PIN # 2 OF S 201 CHANGED TO PIN # 6	R D
C	1112 UP	3-25-60	OMITT T 201, T202 T203, ADD T 204-5	R D

V206 → 9 → 4-5 "U" T205

V203 V209 → 9 → 4-5 → 9 → 4-5 "V" T205

V205 V212 V208 V213 → 9 → 4-5 → 9 → 4-5 → 9 → 4-5 → 9 → 4-5 "W" T205

POWER SUPPLY REGULATORS DRWG 1018C

V210 → 3 → 4 "Z" T205

V211 → 8 → 4-5 "W" T205

INTERNAL OSCILLATOR BRD. DRWG 1058C

V304 → 8 → 4-5 "W" T205

V302 V303 → 3 → 4 → 3 → 4 "Z" T205

AC-DC CONVERTER CHASSIS DRWG 1048C

V-707 V-708 → 2 → 1 "Y" T205

V-709 V-710 → 2 → 1 "X" T205

V-701 V-703 V-704 V-705 V-706 → 3 → 4-5 → 4-5 → 4-5 → 4-5 "Z" T205

POWER AMPLIFIER CHASSIS DRWG 1024C

V-102 V-103 V-104 → 2 → 4-5 → 4 → 3 "Z" T205

LINE NEUTRAL E
OVEN HEATER D
CHOPPER DRIVE C

SERVO AMPLIFIER CHASSIS DRWG # 1026 C

T204

CR-233 — 75Ω 2W R-245 — 100Ω 20W R-246 — 1500Ω 25W R-247 → F +280 UNREG. DRWG# 1026

40 MFD C-207A — 80 MFD C-207B

H COMMON ALL DRAWINGS

CR-231 → +400 DRWG-1018 C PIN 9

CR-230 — 400Ω R-231 — 400 20 ~~250 10W~~ R-202 — 30K 10W R-204 → +105 P DRWG 1018-C PIN 10 J203

40 MFD C-201A — 40 MFD C-201B — 50K 10W R-203

OB2 V-202 (1-5, 2-4-7) — .05 400V C-202

CR-231 — 40MFD C-203A — 40MFD 50MFD C-203B — C-205 — 220K R-286

CR-232 — 10K 2W R-206 — 390K 1W R-250 → K -27 DRAW 1048

15K 10W R-207 → L -105 DRAW. 1024-C

Q -200 DRAWG. 1024-C

T205

15 BRN/WHT "U" DRWG 1019C 6.3 VAC @ 150 VDC

16 GREEN
13 BRN/WHT "V" DRWG 1019C 6.3 VAC @ 250 VDC

14 RED
11 BRN/WHT "W" DRWG 1019C 6.3 VAC @ 105 VDC

12 BRN
17 ORN/BLK
18
19 ORN/BLK — 3Ω 5W — 2000 MFD C-206 — COMMON → 4-5 V-101 SERVO AMP. 9 → 3 V-301 CONVERTER 4

CR-239 — CR 240

5 BRN/WHT "X" DRWG 1019C 6.3 VAC @ CATHODE V709-10

6 PINK
7 BRN/WHT "Y" DRWG 1019C 6.3 VAC @ CATHODE V707, V709

8 BLUE
9 BRN/WHT "Z" DRWG 1019C 6.3 VAC @ GROUND

10 YELLOW

4 AMP. F-202 — 6 — H — 15 — 1 — 3 — K-201 — 2

POWER DS-202

READY DS-203

.05 C-208 — 37 — 6 — 1 — S-201

POWER S-203

2 AMP F-201

P-201

FAN B-204

HOLT INSTRUMENT LABORATORIES
OCONTO, WISCONSIN

MAT'L.		TITLE POWER SUPPLY	
FIN.		DATE 9-26-59	MODEL AVS-321
TOLERANCE UNLESS NOTED FRACT. DEC. SCALE		APPROVED	DRAWING NO. 1019C
		DRFT R.D.	CHNG. C